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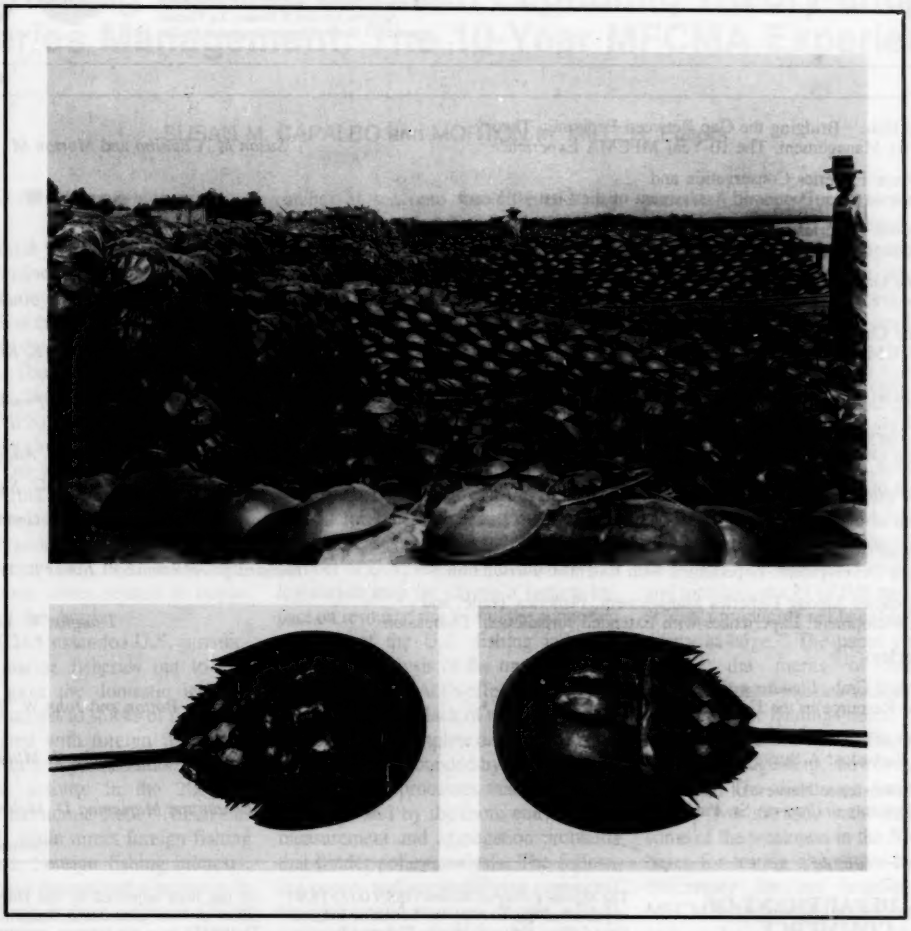
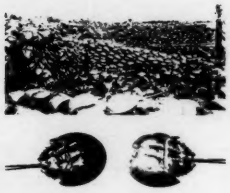


The Horseshoe Crab

Marine Fisheries REVIEW



On the cover: Horseshoe crab photographs by Judith Krzynowek, NMFS Northeast Fisheries Center, Woods Hole, Mass. Top, hundreds of thousands of horseshoe crabs for fertilizer, June 1924. Photograph courtesy of Delaware State Archives, c/o Carl N. Shuster, Jr., Virginia Institute of Marine Science, Gloucester Pt., Va.

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U.S. DEPARTMENT OF COMMERCE

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Bridging the Gap Between Economic Theory and Fisheries Management: The 10-Year MFCMA Experience

SUSAN M. CAPALBO and MORTON M. MILLER, Editors

Preface

This Special Section of the *Marine Fisheries Review* contains the edited proceedings of a symposium held 18 September 1986 at the annual meetings of the American Fisheries Society, in Providence, R.I. The symposium was sponsored by the National Marine Fisheries Service (NMFS) of the National Oceanic and Atmospheric Administration (NOAA). The aims were twofold: To provide a partial economic assessment of the effectiveness of the Magnuson Fishery Conservation and Management Act (MFCMA), enacted in 1976, and to highlight economic issues related to implementation of the Act.[1]

The MFCMA extended U.S. jurisdiction over marine fisheries out to 200 miles and gave the domestic industry preferential access to stocks of fish traditionally shared with foreign fishermen. Since the Act's implementation in early 1977, U.S. activity in the 200-mile "Exclusive Economic Zone" (EEZ) has accelerated, while direct foreign fishing has declined. Foreign fishing interests, however, have maintained a presence in the EEZ through joint ventures (JV's) with U.S. operators. Under the JV's, U.S. fishermen contract to off-load their catches at sea onto foreign processing vessels. From modest beginnings in 1979-80, JV catches grew to nearly 1 million metric tons (t) in 1985, which amounted to approximately one-fourth of total U.S. catches in the EEZ. More recently, new U.S. factory ships have been placed in service on both coasts and this can lead to a further reduction in foreign fishing operations in the EEZ.

Ten years is not an overly long period upon which to base rigorous empirical assessments of the MFCMA. The reduction in foreign fishing and other trends (e.g. increases in U.S. catches and in the number of U.S. vessels) indicate that this legislation may be having a lasting impact on resource stocks and the economic viability of the U.S. fishing industry. However, analysis of the trends and assessments of the Act's effectiveness have been limited by a lack of monitoring procedures and incomplete data. These difficulties are compounded by the stochastic nature of the processes that need to be modeled, and by the more conventional measurement and aggregation problems that hinder policy analysis. The following papers and accompanying comments recognize (and to some degree reflect) these analytical hazards. Nonetheless, we, the editors, believe the papers and comments are an insightful contribution to the literature on fisheries management, and a useful starting point for more advanced evaluations of the effectiveness of MFCMA.

In the first paper, Jon Conrad observes that there were significant increases in landings and net revenues in the 7-year period following enactment of the MFCMA (1977-83). However, net revenues have begun to decline, and ". . .the industry and resources on which it is based appear headed toward a second (but now purely domestic) equilibrium." Under these conditions, ". . .revenues equal cost and the imputed value of the resource is driven to zero (rent dissipation)." Conrad is wary of current management policies which he believes are "ineffective in limiting catch to a target yield and controlling the entry of vessels or the level of fishing effort." New policies are required with ". . .the potential to encourage efficient (least cost) harvests and maintain stocks of fish and shellfish at levels producing net benefits to the industry at large." The paper goes on to discuss the merits of introducing incentive-based policies such as transferable quotas or landings taxes.

The search for a better approach to fishery management, however, can be difficult. The discussant for Conrad's paper, Ivar Strand, calls attention to some of the weakness in the NMFS data bases for testing alternative hypotheses concerning the net benefits of the MFCMA. He also cautions against drawing conclusions based on weak lines of causality. Simple "before-after" comparisons should be avoided. Measures of the difference between the value and the distribution of the gains or losses that would have occurred with the policy and without the policy are required to make more useful policy evaluations. Comparisons need to be adjusted for factors other than the exogenous policy which

[1]Proceedings were dedicated to Frederick J. Prochaska, distinguished scholar and author of many works in food and resource economics and related fields. Dr. Prochaska was known especially for his contributions to knowledge and understanding of the complexities of fisheries management. His untimely death, prior to the meetings, has left a void in the fisheries and academic communities

may have affected observed gains and losses in the period since the MFCMA was enacted.

The second paper in the series, written by Lee Anderson, inquires whether the Act is adequately structured to assure "good" fishery management in terms of how well the process applies what Anderson calls "lessons to be learned from economic theory." Anderson acknowledges that criteria for good management cover broad areas in the physical and social sciences. Good management may represent a blend of approaches upon which all can agree, with emphasis on implementation, or "getting something into place." Bridging "the gap between economic theory and practical fisheries management" could produce better management decisions, but this is not likely to occur unless managers are convinced that rational economics is essential to the decision-making process.

Fishery management plans and regulations reflect the interplay of various forces that often are in conflict. Resource users (the fishermen) continually interact with resource managers, and the behavior of both is constrained by the biology of the fish stocks. This system, according to Anderson, is further constrained by an institutional framework within which users and regulators operate. Anderson's paper discusses how institutional constraints influence fishery management decisions. He calls his analysis a "political bioregunomics approach" which expands upon the bioeconomic model by adding to it the institutional structure which develops fishery management and development policy."

James Kirkley, in commenting on Anderson's paper, agrees that nonrational management is a distinct possibility under MFCMA. Kirkley believes the fault lies not so much with MFCMA per se, but with elements of the infrastructure that is responsible for implementing the legislation. Neither the Regional Councils (which are the primary developers of management plans and regulations) nor NMFS (which develops the scientific and technical information that supports plan development and monitors the regulation process) appear to place adequate emphasis on the importance of economic analysis.

James Easley and Fred Prochaska are coauthors of the next paper which addresses problems in the allocation of allowable harvests among user groups. They point out that fishery managers are reluctant to use available economic methodology to help resolve conflicts between competing groups. Economists, for example, have made considerable headway in devising ways to estimate the economic value of recreational fishing where no direct market transactions for the fish occur. This methodology is directly applicable to the resolution of conflicts between recreational and commercial fishermen, but fisheries managers remain skeptical. The authors cite reasons why the managers resist economic methodology, among which is poor communication between economists and managers. Ways to improve communications are suggested.

In discussing the Easley and Prochaska paper, James Anderson draws upon his own experience with recreational-commercial conflicts in the salmon fishery. He underscores the need for more rigorous modeling of the objectives and behavior of user groups in the regulated climate by drawing parallels to the research conducted by industrial organization economists and game theorists.

The fourth paper, written by Jon Sutinen, examines the pattern of expenditures on enforcement of MFCMA regulations and the efficiency of enforcement programs. Enforcement of marine fisheries regulations cost the Federal government more than $130 million annually. The paper provides an overview of existing enforcement policy and programs and describes a framework for benefit-cost evaluation. A model is presented for measuring the effects of regulatory and enforcement policies on compliance and benefits.

Sutinen's paper also points out that shortcomings in existing data constitute a major deterrent to more complete benefit-cost evaluations of the federal enforcement effort. Adequate data exist only for an analysis of expenditures on enforcement of foreign fishing regulations. Foreign vessels are assessed fees for the privilege of fishing in the EEZ. Sutinen examines the foreign fee structure and concludes that the amount collected from the foreign fishing operators does not fully compensate for the amount spent on enforcement of foreign fishing regulations. Higher fees or a lower level of enforcement may be needed to balance outlays against income. The accompanying comments by Louis Goodreau call further attention to inadequacies in MFCMA enforcement. Goodreau suggests that an independent enforcement entity may be less costly than existing arrangements with the U.S. Coast Guard.

In the last paper in the series, Richard Johnston and James Wilson identify and discuss the linkages between fisheries management, fisheries development, and fisheries trade. The paper examines the effects of extended fisheries jurisdiction on world trade. The authors demonstrate that macroeconomic factors such as exchange rates and the overall performance of the economy are the predominant factors determining patterns of trade. They also point out that extended jurisdiction may influence trade patterns through its impact on the structure of property rights. The United States, for example, sanctions joint ventures and supports a "counter trading" strategy (known as "fish and chips") which links harvest allocations to trade concessions.

In his comments on the Johnston and Wilson paper, Douglas Lipton calls attention to the impact that protectionist import policies and export development have on domestic fisheries. Given the nature of the ownership rights and interplay of a varied set of government policies, it is not clear that the neoclassical relation between output prices and quantities supplied hold; that is, the quantity supplied may fall in response to an output price rise if the fishery is operating on the backward bending portion of the long-run supply curve.

The papers and discussants' comments, as a whole, leave a clear impression that the authors believe a "gap" does indeed exist between economic theory and fisheries management, as the title of the symposium suggests. Although the dimensions of the gap are only partially defined, enough is presented to make a case for more extensive use of economic analysis in the management process, prior to decisions and as a monitoring device to evaluate the impacts of the decisions. It is the hope of editors that these proceedings will encourage further empirical analysis of MFCMA, in the interest of effective fishery management.

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The Magnuson Fisheries Conservation and Management Act: An Economic Assessment of the First 10 Years

JON M. CONRAD

"...introducing extended jurisdiction by itself will not immediately restore fish stocks off our coasts, nor will it necessarily inject new vigor into our fishing industry. The ability to restrict foreign vessels from fishing off our coasts will be only a stopgap measure if proper management of national boats is lacking. Extended jurisdiction authority is an important first step, but it will be meaningless unless proper fishery management is instituted..."

The above opinion was offered by Lee Anderson in the editorial introduction to the volume "Economic Impacts of Extended Fisheries Jurisdiction" (Anderson, 1977:v).

The objective of this paper is to make an assessment of the economic performance of the U.S. fishing industry in the 10 years since the passage of the Magnuson Fisheries Conservation and Management Act (MFCMA). Has the law increased net benefits for the U.S. fishing industry above what they would have been? Have the stocks of fish and shellfish within the fishery conservation zone (FCZ) recovered from the low levels induced by U.S. and foreign overfishing? Do the management policies currently employed under the MFCMA contribute to effective future management or has "Anderson's Prophecy" come to pass?

In the first section I briefly review the factors which led to the passage of the MFCMA and the management institutions and procedures which were created or evolved under that act. In the second section, I review the static and dynamic theory of open access. This theory provides a useful conceptual framework to evaluate what has happened and what is likely to happen under the MFCMA, as currently in force.

In the third section I assemble data to try to determine what has happened to the U.S. fishing industry since enactment of the MFCMA in 1976. These data suggest that 1) the MFCMA resulted in a significant increase in landings and net revenues for the U.S. fishing industry during the seven-year period 1977-83, 2) net revenues, however, are declining and that the industry and resources on which it is based appear headed toward a second (but now purely domestic) open access equilibrium, and 3) current management policies are ineffective in limiting catch to optimum yield.

In the final section I offer recommendations for new policies to manage single and multispecies fisheries which have the potential to encourage efficient (least cost) harvest and to maintain stocks of fish and shellfish at levels producing positive net benefits to the industry and society at large.

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The MFCMA: Background, Enactment, and Management Policies

During the 1960's and early 1970's it became evident that the U.S. commercial fishing industry had gone into serious decline in terms of historical landings and the age and efficiency of vessels in the industry. Much of the blame for this state of affairs was placed on the distant-water fleets of foreign countries. Large, modern trawlers and factory vessels, often subsidized by foreign governments, were accused of unfair competition and overharvesting the fish and shellfish resources that had traditionally supported the smaller nearshore vessels that comprised the U.S. fleet. International management organizations (such as the International Commission for the Northwest Atlantic Fisheries—ICNAF) were often viewed as ineffective, and a situation of de facto open access was thought to exist.

ABSTRACT—The Magnuson Fisheries Conservation and Management Act was enacted in 1976 and implemented in 1977. In an analysis of data collected by the National Marine Fisheries Service one observes a significant increase in the landings of fish and shellfish and in nominal and real ex-vessel revenue. The present value of net variable revenues for the 1968-76 period was estimated at $1.1 billion compared with $3.8 billion for the 1977-85 period. The increase in net revenues, however, appears to be declining due to the increase in the number of vessels in the U.S. domestic fleet. The time path for net revenues suggests that the industry is headed toward a new (purely domestic) open-access equilibrium where revenue equals cost and the imputed value of the resource is driven to zero (rent dissipation). It is well known that open access results in welfare losses to both consumers and the fishing industry. If these welfare losses are to be avoided, the eight regional management councils and the Department of Commerce must adopt policies which will reduce yield in the short run (thereby allowing stocks to increase) and efficiently harvest optimum yield in the long run. Transferable quotas for single species fisheries and transferable effort quotas (rights) in multispecies fisheries are attractive because they encourage efficient (least cost) harvest and afford flexibility in a world where the stocks of individual species are subject to fluctuation.

(Under open access there is no regulation of effort or catch and individual vessels are helpless to effect conservation measures which might lead to increased stocks and ultimately larger yields).

The intense competition for fish and shellfish was not limited to the nearshore waters of the U.S. coast. Several South American countries had unilaterally extended their territorial waters 200 miles seaward from their coastlines in an attempt to restrict access to tuna and anchovy resources. Congressmen from coastal states were under increased pressure in the early 1970's to write and enact legislation which would provide exclusive harvest rights to the U.S. vessels over a comparable coastal zone. While the United Nations had convened conferences on the Law of the Sea (UNCLOS) in 1958, 1960, and 1973, progress was painfully slow and the rate of "enclosure" continued to accelerate on a unilateral (country-by-country) basis.

On 13 April 1976 President Gerald Ford signed into law the Fishery Conservation and Management Act (now called the Magnuson Fishery Conservation and Management Act in recognition of the important contributions by former U.S. Senator Warren Magnuson in the drafting and enactment process). As amended, the law (PL 94-265) provides for exclusive Federal management of all fishery resources (except migratory species of tuna and whales) within a fishery conservation zone (FCZ) extending from 3 n.mi. to 200 n.mi. from shore. (The FCZ has been modified off the coasts of Texas, Puerto Rico, the Gulf side of Florida and in the Gulf of Maine where the boundary line between Canada and the U.S. was recently arbitrated by the World Court).

Eight regional Fishery Management Councils were created and charged with the task of preparing management plans for the species of commercial or recreational importance in their region. After a Council develops a fishery management plan (FMP), covering both domestic and possibly foreign fishing, it is submitted to the Secretary of Commerce for approval and implementation. The Secretary of Commerce may develop a preliminary fishery management plan (PMP) which covers only foreign fishing in the FCZ, or, if a Council fails to produce a FMP in a timely fashion, the Secretary is empowered to produce a FMP covering both domestic and foreign fishing.

Foreign fishing in the U.S. FCZ is permitted if the U.S. domestic fleet is unable or uninterested in harvesting the optimum yield (OY) for a particular species or species complex. In cooperation with U.S. Department of State, the Department of Commerce can negotiate with an interested foreign country a Governing International Fishery Agreement (GIFA) for that portion of OY that will not be harvested by U.S. vessels. After approval by the President it is sent to Congress for review. If no objections are raised by Members of Congress of the affected coastal states, the foreign country may then apply for a permit for each vessel that will be fishing or receiving fish from U.S. vessels in the FCZ (the latter situation would occur under a "joint venture").

Various fees are collected from foreign countries operating in the FCZ. There is an application fee for each foreign vessel fishing or receiving fish in the FCZ. A poundage fee is charged for foreign vessels actually engaged in fishing. A surcharge fee has been charged in the past to capitalize a fund which can be used to compensate a U.S. fisherman who suffers damage to a vessel or gear from foreign vessels operating in the FCZ. Finally, an observer fee is charged to cover the cost of monitoring foreign fishing through U.S. nationals acting as observers aboard foreign vessels.

The regional Fishery Management Councils are composed of members appointed by the Secretary of Commerce and the governors of the coastal states within the region. Appointments are made so that the council has representation from the fishing industry, processors, sportfishing associations, and other concerned (and politically influential) groups. Each council has a small staff headed by an executive director. The council can contract for studies of the industry or resources in their region and will also draw on the expertise of a scientific committee in developing a FMP. Two or more councils may work together in developing a plan for a species that migrates or is harvested in more than one region. After development, a FMP is subject to public review and comments are taken in writing or at public hearings.

To date, the FMP's have relied on a variety of management policies including annual quotas, quarterly quotas, trip quotas, closed areas, size limits, and net mesh size in an effort to restrict catch to an amount less than or equal to optimum yield. Optimum yield is that rate of harvest that "(1) will provide the greatest overall benefit to the United States, with particular reference to food production and recreational opportunities, and (2) is prescribed as such on the basis of maximum sustainable yield from such fishery as modified by any relevant ecological, economic, or social factors." The second clause seems to have guided the deliberations of most councils in determining OY, although the precise influence of the relevant ecological, economic, and social factors is difficult to identify, ex-post.

As of 1 January 1986 there were 25 fisheries being managed under FMP's and 7 being managed under PMP's. Many of the earlier FMP's have been amended since initial implementation as a result of unanticipated changes in the resource stock or industry. A detailed assessment of the success or failure of each FMP is beyond the scope of this paper. Instead we will examine what has happened to the industry in terms of aggregate measures such as landings of fish and shellfish, ex-vessel revenue, number of registered vessels and variable cost. Before examining the data it will be helpful to review the economic theory of open access.

Open Access

Prior to passage of the MFCMA it was maintained that the competition between U.S. and foreign flag fishing vessels had reduced offshore stocks of fish and shellfish to levels where the ex-vessel revenues received by fisherman just covered the costs of fishing. Such a situation is symptomatic of open access—where harvest is essentially unregulated and vessels enter the fishery (or existing vessels increase fishing effort) until net revenue is driven to zero.

The tendency of a common property fishery to evolve toward an open access (zero profit) equilibrium was first dis-

cussed by Gordon (1954). Gordon referred to this process as one of "rent dissipation" because the resource was harvested to a level where competitive vessels, only covering the costs of fishing, would be unable to pay (rent) for the right of access. If the resource were owned (by a private individual or by a government agency acting on behalf of its citizens), it would charge fishermen some amount for the right to harvest some portion of the resource stock. Under ownership or agency management the resource has value equal to the present value of future expected rents. Under open access, however, the dissipation of rents implies that the resource has been economically overfished to the point where it can earn no rent and is thus worthless.

It can be shown that open-access equilibrium is nonoptimal. There will be too many vessels chasing too few fish. If harvest could be restricted and stocks increased, it would be possible to compensate (buy out) the vessels who left the fishery and still have money (rent) left over.

The analysis by Gordon (1954) was essentially a static or equilibrium analysis. Smith (1968) presented a dynamic model represented as a system of two differential equations. Suppose X represents the biomass of some species at time t, and E represents the level of fishing effort. The resource is presumed to exhibit net growth without fishing according to the function $F(X)$. The rate of harvest (fishing mortality) is given by the production function $H(X,E)$. Thus, the rate of change in biomass is given by the differential equation

$$\dot{X} = F(X) - H(X,E) \qquad (1)$$

The change in effort (perhaps measured by vessels, vessel-days, or net-hours) is presumed to depend on the level of net revenues (profit rate). In particular, if net revenues are positive effort will expand, while if net revenues are negative effort will contract. Suppose the price per pound for a ton of fish at the dock (that is, the ex-vessel price) is given by p while the cost of effort is given by k. Then, since $H(X,E)$ represents the rate of harvest, $pH(X,E)$ represents ex-vessel revenue, while kE represents cost. The rate of change in effort might be described by the differential equation

$$\dot{E} = n[pH(X,E) - kE] \qquad (2)$$

where $n > 0$ is a "stiffness" parameter indicating the response of effort to net revenue. Taken together, equations (1) and (2) comprise a two-dimensional (planer) nonlinear dynamical system. If p, k, and all other parameters are time-invariant, the system is autonomous and the identification and stability analysis of stationary states might be accomplished by phase plane analysis.

For a general system similar to equations (1) and (2), Smith (1968) noted the possibility of multiple equilibria, some stable and some unstable. Open access extinction was a possibility if it were profitable to expand effort at low stock levels or if vessels did not leave an unprofitable fishery rapidly enough.

Consider the Gordon-Schaefer model (Clark, 1976:203 and 1985:16) where

$$\dot{X} = rX(1-X/K) - qXE \text{ and} \qquad (3)$$

$$\dot{E} = n(pqXE - kE) \qquad (4)$$

The net growth function is thus $F(X) = rX(1-X/K)$ which is the logistic function where r is the intrinsic growth rate and K is the environmental carrying capacity. The production function is $H(X,E) = qXE$ where q is the catchability coefficient. As before, the parameters p, k, and n represent the per-unit price for landed fish, the per-unit cost of effort, and the adjustment parameter. The isoclines of Gordon-Schaefer model are obtained by setting $\dot{X} = 0$ and $\dot{E} = 0$, with the latter immediately implying that the stationary (equilibrium) stock under open access is $\bar{X} = k/(pq)$. The isocline associated with $\dot{X} = 0$ is given by the line $E = r(1-X/K)/q$ and thus the stationary level of effort under open access is $\bar{E} = r(1-\bar{X}/K)/q$. The isoclines are drawn in the phase-plane diagram in Figure 1.

The equilibrium $(\bar{X},\bar{E})$ is stable (a node or spiral). Limit cycles are precluded by the Bendixon-du Lac test (see Clark, 1976:203-204). Figure 1 shows a spiral covergence to $(\bar{X},\bar{E})$. When $X<\bar{X} = k/(pq)$, net revenues are negative and effort decreases, while when $X>\bar{X} = k/(pq)$ net revenues are positive and effort

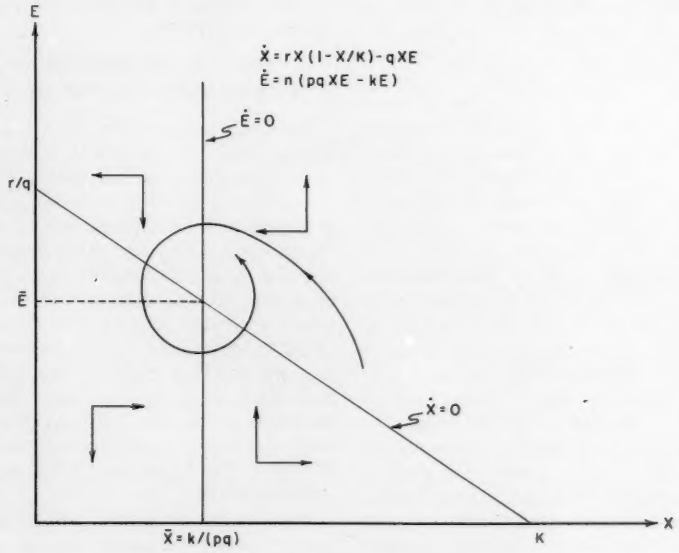

Figure 1.—A phase plane diagram for the system.
$\dot{X} = rX(1 - X/K) - qXE$
$\dot{E} = n(pqXE - kE)$

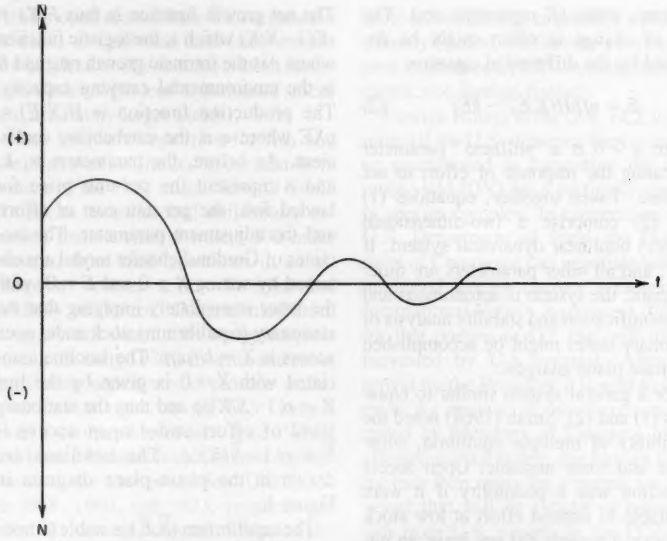

Figure 2.—The time path for net revenues for spiral convergence to open access equilibrium.

increases. A possible time path for net revenues is shown in Figure 2. It exhibits a damped oscillation as net revenues are driven to zero as $X \rightarrow \overline{X}$, $E \rightarrow \overline{E}$, and $t \rightarrow \infty$.

In any empirical investigation price, cost and other parameters will be changing. Individual stocks of fish and shellfish often show significant fluctuation presumably due to stochastic environmental conditions. It is unlikely, therefore, that a "real world" fishery would ever exhibit convergence to a stationary point. In a changing, stochastic world open access might be characterized by more or less random fluctuations in net revenue about $N = 0$ (the t-axis in Figure 2), as the resource stock, price, or cost is subject to random variation.

Empirically, then, if a fishery has exhibited damped oscillation toward zero net revenues or random fluctuation about zero net revenues, a strong case might be made for de facto open access. Policies which increase expected net revenue (thus fishery rent) would be consistent with a move toward improved fishery management. (Policies which reduce the variance of net revenues would presumably confer benefits to risk averse individuals). What evidence can be assembled on the status of U.S. commercial fisheries both before and after implementation of the MFCMA?

The U.S. Commercial Fishing Industry: 1968-85

An economic assessment of the U.S. fishing industry is made difficult because of the large number of independent vessels employing often vastly different gear to harvest over 100 different species of finfish and shellfish. The NMFS definition of a vessel is any craft of 5 net tons or greater. In 1977 there were 17,545 vessels registered with the U.S. Coast Guard for commercial fishing. The vast majority, 13,235 or 75 percent, were less than 50 gross registered tons (GRT). The modal and median class (cell) was 10-19 GRT while the average vessel was 43.7 GRT. The largest vessel class was 3,270-3,279 GRT.

These vessels do not fish year round and may change gear and fisheries within a single year. In a 1982 study of 60-100 GRT otter trawlers, Mueller et al. reported an average of 158.6 days absent from port and an average of 98.2 days fishing during the 5-year period 1976-80[1]. Thus, the number of vessels in the industry is a very crude measure of fishing effort. Its only advantage is that NMFS data on vessel numbers exists for the period 1968-84. We will use the symbol E_t to denote the number of vessels in year t, where $t = 0$ corresponds to 1968 and $t = 17$ corresponds to 1985.

The NMFS also keeps track of total landings of fish, shellfish, and ex-vessel revenue. Given the highly decentralized nature of the U.S. fishing industry and the tax incentive for cash transactions, one can safely assume that the reported data for landings and ex-vessel revenues understate the amount and value of U.S. catch. The extent of the understatement is not known. We will denote the aggregate landings of fish and shellfish (exclusive of mollusk shell weight) by Y_t and ex-vessel revenue by R_t.

Given estimates of Y_t and R_t one can obtain an average price $p_t = R_t/Y_t$. With Y_t measured in metric tons and R_t in dollars, p_t is interpreted as the price per metric ton ($/mt).

An important time series not estimated annually by the NMFS is industry cost. Given the diversity of vessel size, design, and gear operation, this is understandable. The NMFS will periodically conduct studies into the costs and returns of various types of vessels operating in the major commercial fisheries. In addition, the aforementioned report by Mueller et al.[1] describes a financial simulator which has been used to estimate vessel costs based on design and operating characteristics, days absent from port, cost of food, fuel, and ice and other variable and fixed-cost components.

In 1977 the NMFS reported that the variable cost of operating a 42 GRT trawler in 1974 was $44,901. Since the trawler is a dominant vessel type, and the "average" vessel in 1974 was 43 GRT, this variable cost figure was used as an initial condition to generate variable vessel cost for other years. Let k_t denote the variable vessel cost in year t. Then the difference equation

[1]This analysis was reported by Mueller, et al. in "Some notes on modeling the financial performance of commercial fishing fleets," National Marine Fisheries Service, Northeast Regional Office, Gloucester, Mass. 1982.

Table 1.—Definition of variables in Table 2.

t = year index $t = 0$ (1968) *to* $t = 17$ (1985).
Y_t = yield of fish and shellfish (10^6 metric tons (t)), exclusive of mollusk shell weight.
R_t = ex-vessel revenue (10^9) in year t.
p_t = average price ($/t) for finfish and shellfish in year t.
E_t = number of vessels ≥ to 5 net tons in year t.
CPI_t = consumer price index (1967 = 100) in year t.
k_t = variable operating cost of a 42 gross registered ton (GRT) trawler ($/vessel) in year t.
C_t = total variable cost (10^9) for industry in year t.
N_t = net revenue (10^9) for industry in year t.

$$k_{t+1} = [1 + (CPI_{t+1} - CPI_t)/CPI_t]k_t \quad (5)$$

where CPI_t denotes the consumer price index (1967 = 100) was used to generate variable vessel costs for all other years (1968-73 and 1975-85).[2]

Knowing the number of vessels E_t and the variable cost of the average vessel, k_t, one can estimate variable cost for the industry as $C_t = k_t E_t$. Net revenue, denoted by N_t, can be calculated as $N_t = R_t - C_t$. This is actually net variable revenue, and the vessel owner would need to cover fixed costs and taxes from net variable revenue. Given the wide range of fixed costs and taxes for similar vessels, no attempt was made at estimation. (Economic theory would suggest that the fishing decision in a given year would be based on variable cost considerations, although future investment decisions would require fixed costs to be covered as well.)

Table 1 provides a summary of notation and definition of variables. Table 2 contains data on Y_t, R_t, p_t, E_t, CPI_t, k_t, C_t, and N_t, for the period 1968-85. Table 3 contains notes on the sources and methods of calculation for the data in Table 2. Figures 3-7 present graphs of the time paths for Y_t, R_t, E_t, C_t, and N_t.

Table 2.—The U.S. commercial fishing industry, 1968-85.

t (Year)	Y_t (10^6t)	R_t (10^9)	p_t ($/t)	E_t (No. of vessels)	CPI_t (1967=100)	k_t ($/vessel)	C_t (10^9)	N_t (10^9)
1968	1.9	0.5	263	13,150	104.2	31,675	0.4	0.1
1969	1.9	0.5	263	13,187	109.8	33,378	0.4	0.1
1970	2.2	0.6	272	13,591	116.3	35,354	0.5	0.1
1971	2.3	0.7	304	14,008	121.3	36,874	0.5	0.2
1972	2.2	0.7	318	14,507	125.3	38,090	0.6	0.1
1973	2.2	0.9	409	15,367	133.1	40,462	0.6	0.3
1974	2.3	0.9	391	15,891	147.7	44,901	0.7	0.2
1975	2.2	1.0	454	16,211	161.2	49,005	0.8	0.2
1976	2.4	1.3	541	16,875	170.5	51,832	0.9	0.4
1977	2.4	1.5	625	17,545	181.5	55,176	1.0	0.5
1978	2.7	1.9	703	18,100	195.4	59,401	1.1	0.8
1979	2.8	2.2	785	18,400	217.4	66,088	1.2	1.0
1980	2.9	2.2	758	18,900	246.8	75,025	1.4	0.8
1981	2.7	2.4	888	19,500	272.4	82,807	1.6	0.8
1982	2.9	2.4	827	20,400	289.1	87,883	1.8	0.6
1983	2.9	2.4	827	21,100	298.4	90,710	1.9	0.5
1984	2.8	2.3	821	24,000	311.1	94,570	2.3	0.0
1985	2.8	2.3	821	25,000	322.2	97,944	2.4	0.1
See Table 3	(g)	(g)	(b)	(c)	(d)	(e)	(f)	(g)

Table 3.—Data source method of calculation, and comments on data in Table 2.

(a) Source: "Fisheries of the United States," 1985: p. 3, 36.
(b) Calculated: $p_t = R_t/Y_t$.
(c) Source: "Fisheries of the United States," 1980-85, and "Fishery Statistics of the United States," 1968-77). Comment: The number of vessels reported in 1984 seems suspiciously high. Comment: The number of vessels reported in 1985 is an estimate by the author. No estimate was available from the NMFS during data collection (June 1986).
(d) Source: "The Handbook of Basic Economic Statistics, April 1986, 91-101.
(e) Source: The 1974 estimate of variable cost for a 42 GRT trawler was estimated by the NMFS in "Revenues, Costs and Returns from Vessel Operation in Major U.S. Fisheries," 1977, p. 7, as $44,901. Calculation: Using k_t = $44,901 for $t = 6$ (1974). The other values of k_t were obtained from the difference equation $k_{t+1} = [1+(CPI_{t+1} - CPI_t)/CPI_t]k_t$.
(f) Calculated: $C_t = k_t E_t$.
(g) Calculated: $N_t = R_t C_t$.

Simple analysis of the data in Table 2 provides the following insights into the performance of the U.S. fishing industry in the 9 years before (1968-76) and after (1977-85) implementation of the MFCMA.[3]

Landings of fish and shellfish significantly increased in the post MFCMA period. The mean for landings during the period 1968-1976 was 2.2 million metric tons as compared to 2.8 million metric tons for the period 1977-1985. A simple test for the difference of two means ($H_0: \mu_2 - \mu_1 = 0$, where μ_2 is the unknown mean yield for the ex-post MFCMA period and μ_1 is the unknown mean yield for the ex-ante period) yielded a test statistic of $t^* = 7.57$, leading one to reject equal mean landings at the 1 percent level. The time path for landings is shown in Figure 3. Increased U.S. landings in many fisheries were likely the result of exclusion of foreign vessels. While data is not available for all the major fisheries, on the U.S. east coast foreign landings declined from an annual average of $1,226.1 \times 10^6$ mt for the period 1970-74 to 107.4×10^6 mt in 1982 (NMFS, 1983:13). A similar redistribution (from foreign to U.S. flag vessels) undoubtedly occurred in the Pacific Northwest and Alaska.

Ex-vessel revenue also increased in the post MFCMA period (see Figure 4). The numbers reported in column three in Table 2 are nominal and thus reflect the increase in landings as well as inflation. Deflation by the consumer price index will, however, reveal that real (deflated) revenues also increased. The average for the 1968-76 period was $0.80 billion while it was $2.2 billion (nominal) for

[2]Reviewers have suggested that a more appropriate index to construct estimates of variable vessel cost would be the Producer's Price Index (PPI) or the Fuel Price Index (FPI). The PPI for all commodities was 102.5 in 1968 and 308.8 in 1985 and would generate slightly lower estimates of variable vessel costs. The FPI increased dramatically from 98.9 in 1968 to 634.2 in 1985. This would significantly increase the estimates of variable vessel costs and greatly reduce the estimates of net revenue, especially in the post-MFCMA period. Thus, it should be acknowledged that the estimates of the net revenue will be influenced by the choice of index used in equation (5).

[3]It has been pointed out that because this analysis was conducted at the industry level, it may not be representative of the performance in any specific fishery (e.g. sea scallops). This is technically correct. The same industry data could be generated from an aggregation of very profitable and very unprofitable fisheries. A detailed (micro) financial analysis of even the major commercial fisheries, however, would have resulted in a book-length manuscript, and was thus beyond the scope of the present study.

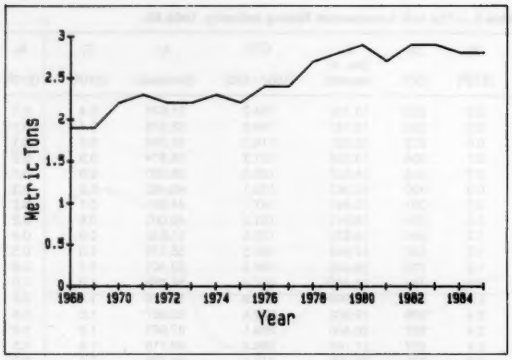

Figure 3.—Landings of fish and shellfish, 1968-85.

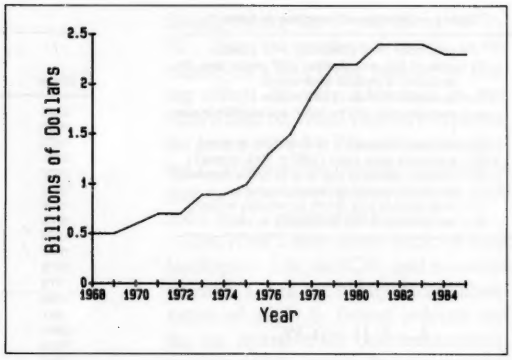

Figure 4.—Ex-vessel revenues, 1968-85.

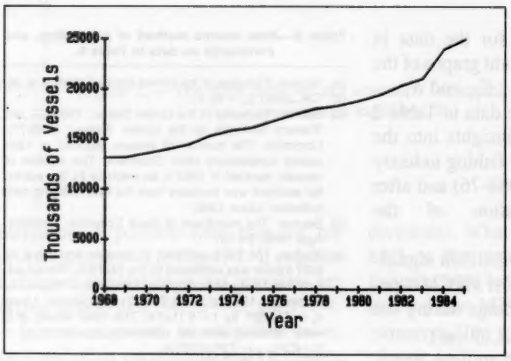

Figure 5.—Number of vessels, 1968-85.

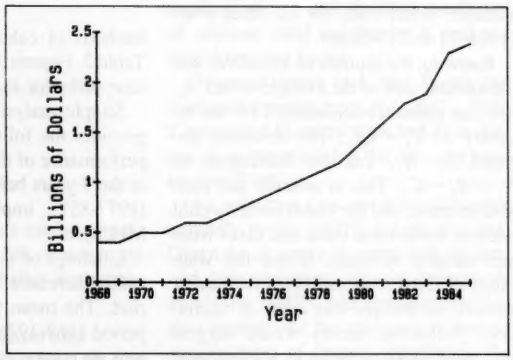

Figure 6.—Variable costs, 1968-85.

the 1977-85 period.

An indication of expected profitability is reflected in the increase in the number of vessels in the U.S. fleet. Even during the pre-MFCMA period there was significant entry. This might reflect current profitability (as in equation (2) in the preceding section on open access) or it may reflect an anticipation of future profits under extended jurisdiction. Certainly by 1973 it was suspected that some form of extended jurisdiction would be unilaterally adopted by the United States. During the 9-year period before implementation, vessel numbers increased by 3,725. In the 9-year period after implementation, the number of vessels increased by approximately 7,455. The time path for the number of vessels is shown in Figure 5.

Industry cost (estimated as the product of average variable cost per vessel times the number of vessels) is shown in Figure 6. The cost of operating our "average" vessel increased over threefold from 1968 to 1985 (see Table 2, column seven). This was the result of general inflation and the dramatic increases in the cost of crude oil and distillate products (including diesel) during the Arab oil embargo (1973-74) and the disruption accompanying the initial stages of the Iran-Iraq War (1980)[4]. In the early 1980's, interest payments on new vessels approached 10 percent of the gross boat share (Mueller, et al.[1]). The increase in industry variable cost in 1984 and 1985 is more influenced by the number of new vessels entering the industry (estimated at 3,900) than by per-vessel cost (which only increased 8 percent over that 2-year period).

Industry revenues, variable costs, and net revenues are shown in Figure 7. There are two interesting aspects about the time path for net revenues. First, net revenues are significantly greater in the post-MFCMA period, particularly during the years 1977-83. Using a 10 percent discount rate the present value of net revenues for the 1968-76 period was

[4]Attaching a higher weight to fuel prices would reduce the estimates of net revenue. See footnote 2.

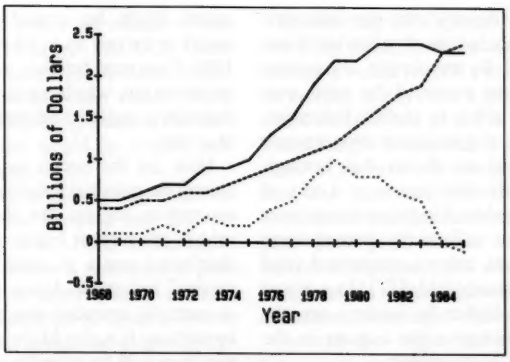

Figure 7.—Revenues, variable costs, and net returns, 1968-85.

$1.1 billion versus $3.8 for the 1977-85 period. While other factors may have contributed to the favorable "bottom line" during the latter period, it seems likely that the MFCMA was the major factor.

The second, more disquieting, aspect is the rapid decline in net revenues in 1984 and (estimated for) 1985. Recall zero net revenues or oscillating (positive and negative) net revenues were symptomatic of open access. It would appear that the U.S. fishing industry may be settling down to a second open access equilibrium. Only now the vessels that are economically overfishing the stocks of fish and shellfish are U.S.-flag vessels and reducing their collective catch will be politically more difficult. Again, the costs of open access are underperformance costs, in the sense that larger yields could be obtained by a smaller fleet fishing a larger stock. This increase in net revenues from a well managed fishery would more than exceed the difference in opportunity costs of those fishermen and vessels leaving the fishery.

In summary, it would appear that the MFCMA did play an important role in increasing industry net revenues during the 1977-85 period. However, the long-term effectiveness of the management plans and policies currently in force is suspect. It would appear that a second, purely domestic open access equilibrium is being approached, along with the associated social cost of under-performance. "Anderson's Prophecy" appears to be borne out by the data on vessel numbers and estimates for net revenues[5].

If the above analysis is an accurate assessment of industry performance under the MFCMA, then it is also an indictment of the management policies embodied in the FMP's and the PMP's. Recall that the objective of the eight regional councils was to encourage harvest of optimum yield (OY). To define optimum yield in a single-species fishery, most councils attempted to follow the guidelines in the second clause of the definition; that is, to determine maximum sustainable yield, and then make appropriate modifications based on the relevant "ecological, economic or social factors." While these latter factors introduce elements of imprecision and subjective judgement, they cannot explain the failure of the MFCMA to avoid or reverse the drift toward domestic open access. What went wrong?

There are at least two factors that would contribute to the ineffectiveness of management based on OY. First, the estimates of OY may presume a stock level larger than the current stock and a continuation of harvest rates at OY only fostered a continued decline in the resource stock or, at best, prevented recovery. In other words, yields considerably less than OY might be required to allow stocks to increase before OY could be harvested on a sustainable (yearly) basis.

Second, the dramatic increase in the number of vessels has likely led to an increase in the amount of unreported landings. This is true even if the rate of under-reporting per vessel is unchanged. Reported landings less than OY might be associated with actual landings in excess of OY and ultimately lead to declining stocks.

There are other possible explanations, but if the above two factors were paramount, then steps to improve management under the MFCMA must focus on 1) transitional yields (TY's) which will lead to stock levels capable of supporting optimal yield, and 2) better monitoring and enforcement of catch both in transition (along an approach path) and at optimal yield, once the stock level supporting OY has been reached.

Economists are also interested in policies which promote efficiency; that is, policies which encourage TY's and OY to be harvested at least cost. As it turns out, policies which promote efficiency might also lead to better monitoring of actual catch. We now turn to a discussion of policies to promote and maintain a more efficient industry.

Recommendations for Improving Management Under the MFCMA

Recent theoretical work in bioeconomics is based on a management objective which seeks to maximize the present value of net benefits. Under certain assumptions this objective will be met by finding that stock level which satisfies a "singular solution," and setting transitional yield at zero if current stock is less than the optimum, or harvesting at a maximum rate if current stock is greater than the optimum. In other words, it is

[5] It should be emphasized that this is a "before and after" analysis which is different from a "with and without" analysis. The latter analysis is actually the preferred analysis for project and impact analysis. It generally requires the construction of a model, such as the open access model, to stimulate what would have happened without a project or policy (in our case, the MFCMA). One approach would be based on empirical estimation of growth and production functions for a fishery and simulating the difference equation analogue of equations (3) and (4) forward in time given actual observations on per unit prices and costs. For an empirical study of the North Sea herring fishery, see Bjørndal and Conrad (1987).

optimal to approach the optimal stock as rapidly as possible (Clark, 1976:39-41).

The optimal stock within a bioeconomic model will typically depend on price, cost, parameters of the growth and production functions, and the discount rate. The optimal stock may be greater than or less than the stock associated with maximum sustainable yield (MSY). This will depend on the magnitude of the "marginal stock effect" relative to the discount rate (Clark and Munro, 1975). In an empirical study of tuna in the eastern tropical Atlantic, Conrad and Adu-Asamoah (1986) have estimated that the optimal stock exceeds the MSY stock. This is attributable to cost savings afforded by fishing a larger stock.

The operational objective under the MFCMA is to manage coastal fishery resources so they provide an optimal yield (OY) equal to MSY plus or minus some amount to reflect ecological, social, or economic considerations. Thus, the objective under the MFCMA is not inconsistent with the optimal stock which might emerge from application of the simple bioeconomic model. The management policies espoused by economists to achieve and maintain fish stocks near the optimal level, however, are different from those usually recommended by biologists and those which have dominated applied management under the MFCMA.

The key to understanding economic policies for fishery management is "user cost" (Conrad, 1986:390-396). User cost reflects an incremental cost imposed in future periods because an additional unit of the resource is harvested today. By reducing the stock an additional unit today, you reduce future stock by that unit and by the biological growth it would have provided.

Bioeconomic policies have attempted to introduce economic incentives which would cause fishermen to behave "as if" they were cognizant of user cost. These incentive-based policies, in a single species fishery, include landings taxes and transferable quotas (Clark, 1985:157-175 and Conrad, 1986:395-397). A landings tax is a tax per unit on the harvested resource (e.g., $100 per metric ton of yellowtail flounder landed in New Bedford). A transferable quota is a certificate which entitles the owner to harvest a certain amount of the resource per unit time (e.g., 10 metric tons of yellowtail flounder in 1986). By transferable, economists mean that the owner of the quota may "fish it" or sell it to another fisherman. Within the single-species bioeconomic model it can be shown that landings taxes, transferable quotas, or a mix of both are capable of inducing competitive fishermen to collectively harvest some target amount, either a transitional yield (TY) or optimal yield (OY). In a mixed system, the higher the landings tax, the lower the bid-price for a quota in the transferable quota market.

Management by landings taxes or transferable quotas has the advantage of economic efficiency; that is, they encourage harvest by the lower cost fishermen. With a landings tax only fishermen who can cover costs with "after-tax" revenues would be economically viable. With transferable quotas the lower cost fishermen would be able to offer higher bid-prices and thus, in theory, would be able to purchase the quotas required for fishing.

Under the MFCMA, as currently amended, landings taxes are probably precluded (Christy, 1977:144). Thus, we will focus on transferable quotas in a single species fishery and transferable effort quotas (rights) in multispecies fisheries (such as the groundfish fishery on George's Bank where cod, haddock, flounder, and other species may be harvested simultaneously by otter trawlers).

Suppose we are concerned with a single species fishery where the stock is below the level associated with optimum yield. Fisheries scientists on the Council's scientific committee must determine a level for transitional yield (TY) which allows for escapement and growth which will increase the stock. There are, of course, many possible levels for TY including a zero yield (i.e., a fishing moratorium) which would allow for the "most rapid" approach to the optimal stock. Suppose a moratorium is viewed as too extreme and some TY is adopted which scientists think will allow for some positive level of growth.

The TY must now be divided up into some number of transferable quotas. For example, if TY = 1,000 metric tons of sea scallops, a total of 100 transferable quotas might be created entitling the owner to harvest up to 10 metric tons in 1986. Care must be taken in specifying a quota amount which could be profitably fished by a single vessel during some part of a year.

How are the quotas to be allocated among the potential fishermen? Fisheries economists suggest that they might be sold to the highest bidder at auction or distributed gratis to some set of "deserving" fishermen. Again, the MFCMA as currently amended may preclude sale by auction. It is also likely to be the case that there will be more "would-be" fisherman than quotas. One suggestion is to set up criteria based on a record of historical landings (involvement) in the fishery which would define a set of "legitimate" vessel owners eligible for a lottery. Say there are 200 such eligible vessel owners. After the drawing, 100 of the eligible vessel owners will have received a quota entitling them to harvest up to 10 metric tons of scallops. The 100 eligible vessel owners who do not have a quota would be able to negotiate with quota holders or submit bids to a quota marketing board that would serve as an intermediary between current holders (suppliers) and eligible vessel owners wishing to acquire a quota (demanders).

There are many details which would need to be worked out. Should a limit be placed on the number of quotas which could be owned by a single individual or corporation? Could a quota holder sell a portion of his quota? Should the quotas be annual or for a longer period of time, thereby allowing a longer horizon for planning investments in vessel, gear, and electronics? Should the TY's be specified for more than 1 year in advance, again providing the quota holder with a less risky management environment?

While the answers to the above questions may have significant implications for the price of quotas and the flexibility with which managers have to alter TY's, they should not pose insurmountable problems if the concept of transferable quotas and the lottery-market process is viewed as acceptable. Over time, if initial TY's do allow stocks to recover, then the number of quotas would presumably increase as TY approaches OY.

Transferable quotas may facilitate en-

forcement and reduce the amount of unreported "overfishing." The U.S. Coast Guard would have a list of those vessels with quotas and any other vessels found on or near the fishing grounds of the species in question would be suspect and subject to search.

Management of multispecies fisheries is a much more complex and difficult problem (May et al., 1979). In multispecies fisheries where a nonselective gear harvests two or more species simultaneously, it is difficult to apply a system of transferable quotas on a species-by-species basis. The New England Regional Fishery Management Council will attest to this difficulty. They tried and abandoned quarterly quotas by species, trip quotas by species, and are currently operating under a minimum mesh size for the New England groundfishery. By studying trip-file data it should be possible to estimate the number of days absent or days fished and the likely total number of metric tons of groundfish (cod, haddock, pollock, flounder, and redfish). A transitional yield and associated number of "days-to-be-fished" (DTBF) is specified. The total DTBF is divided into a finite number of "effort quotas." As before, a set of eligible vessels is determined, and a lottery is employed to assign effort quotas specifying the right to fish some number of days. Those vessel owners who did not win in the lottery would be free to negotiate with the holder of an effort quota directly or submit a bid to the administrator of the quota market.

The value of an effort quota (or right) is more speculative than a catch quota in a single species fishery. This is because an effort quota entitles the owner to fish some number of days, but there is no guarantee on catch. No quotas would be levied on individual species and the composition of total catch would be likely to change from year to year. If managers had concerns about the abundance of a particular species within a multispecies complex, analysis of particular grounds may indicate areas which, if closed to fishing, would offer some specific protection to the species of concern. As multispecies biomass increases, the number of DTBF could be increased allowing total catch to increase toward the estimate of OY.

Enforcement of a system of transferable effort rights would be more difficult because it would require a monitoring of the number of days that a quota-holding vessel actually had its net in the water. Vessels might be required to submit "trip plans" to a central office indicating headings and expected time steaming to, from, or between grounds and their home port. Coast guard vessels would be informed of trip plans, and when encountering vessels would determine location and status (steaming or fishing).

In both the single and multispecies fisheries the presence of "natural fluctuations" in fish stocks will present a conflict between managers who wish to frequently change TY's or DTBF in response to fluctuating stocks and fishermen who want to know their future quotas or DTBF with certainty. Both the regional councils and the fishermen will have to maintain flexibility as managers learn about the recruitment effects of previous TY or DTBF quotas. The trade-off would hopefully be between a more profitable fishery, subject to changing management policies, versus a static, low profit, de facto open-access fishery.

Conclusions

Let us return to the three questions posed in the introduction to this paper. The first asked whether the MFCMA increased net revenues above what they would have been during the 1977-85 period. Our conclusion would be "yes," based on our estimates of industry cost and the calculation of a present value for net revenues of $1.1 billion for the 1968-76 period vs. $3.8 billion for the 1977-85 period.

The second question asked if the stocks of fish and shellfish in the FCZ have increased since passage of the MFCMA. This question cannot be answered definitively, but it is likely that stocks have not increased appreciably. The U.S. fleet expanded rapidly and much of the net revenue gains were probably the result of a redistribution of foreign catch to U.S. vessels. The estimated decline in net revenues suggests that the U.S. commercial fishing industry may be converging to a new, purely domestic, open-access equilibrium. Open access results in underperformance costs. There are too many vessels chasing too few fish. The industry and society (the fish-consuming public) would be better off if stocks were allowed to increase and higher yields could be sustained based on larger standing stocks of fish and shellfish.

The third question asked if current management policies adopted under the MFCMA would provide a basis for long-term, positive net benefits. The answer would seem to be "no." While the MFCMA probably precludes landing taxes as a means to "internalize" user cost in the decisions of fishermen, it does not preclude the use of a system of transferable quotas in single species fisheries or effort quotas (rights) in multispecies fisheries subject to nonselective harvest. A transitional yield-lottery program of management is recommended according to the criteria of efficiency (least-cost harvest), flexibility in the face of natural fluctuations, and holding the best promise of providing positive net benefits to the industry and fish-consuming public.

Literature Cited

Anderson, L. G. 1977. Economic Impacts of Extended Fisheries Jurisdiction. Ann Arbor Sci. Ann Arbor, Mich.

Bjørndal, T., and J. M. Conrad. 1987. The dynamics of an open access fishery. Can. J. Econ. 20(1):74-85.

Bureau of Economic Statistics. 1986. The handbook of basic economic statistics. U.S. Dep. Commer., Bur. Econ. Stat. 40(4).

Clark, C. W. 1976. Mathematical bioeconomics: The optimal management of renewable resources. Wiley Intersci. Publ., John Wiley & Sons, N.Y.

_____. 1985. Bioeconomic modelling and fisheries management. Wiley Intersci. Publ., John Wiley & Sons, N.Y.

Christy, F. T. 1977. Limited access systems under the Fishery Conservation and Management Act of 1976. *In* L. G. Anderson (editor), Economic impacts of extended fisheries jurisdiction. Ann Arbor Sci., Ann Arbor, Mich.

_____ and G. R. Munro. 1975. Economics of fishing and modern capital theory: A simplified approach. J. Environ. Econ. Manage. 2:92-106.

Conrad, J. M. 1986. Bioeconomics and the management of renewable resources. Biomathematics 17:381-403.

_____ and R. Adu-Asamoah. 1986. Single and multispecies systems: The case of tuna in the eastern tropical Atlantic. J. Environ. Econ. Manage. 13:50-68.

Gordon, H. S. 1954. Economic theory of a common property resource: The fishery. J. Polit. Econ. 62:124-142.

May, R. M., et al. 1979. Management of multispecies fisheries. Science 205:267-277.
NMFS. 1983. Status of the fishery resources off the northeastern United States for 1982. U.S. Dep. Commer. NOAA, Tech. Memo. NMFS-F/NEC-22.
_____. 1980-85. Fisheries of the United States. U.S. Dep. Commerce, NOAA, Natl. Mar. Fish. Serv., Curr. Fish. Stat., var. no., pagin.
_____. 1968-77. Fishery statistics of the United States. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Stat. Dig., var. no., pagin.
Smith V. L. 1968. Economics of production from natural resources. Am. Econ. Rev. 58:(3):409-431.

The Magnuson Fisheries Conservation and Management Act: An Economic Assessment of the First 10 Years. Discussion

IVAR E. STRAND

Jon Conrad has offered a provocative paper addressing the important issue of the effectiveness of MFMCA. The issue is whether we, as a nation, are attaining any or all of the potential rewards from the resources in our 200-mile economic zone.

The author has provided a well-written theoretical section that should be accessible to persons without much background in economics or mathematics. It also provides a reasonably elegant way to establish a working hypothesis, which is purported to be tested in the empirical section. The hypothesis is that the aggregate net revenues in the fishing industry have increased significantly over the period 1977-85 compared with net revenues over the period 1968-76. If one observes a significant increase in net revenues in the post-MFCMA period, we are to conclude that this is both beneficial to the United States and the result of MFCMA.

Ignoring the proof of causality and the data for a moment, one is still left uncomfortable with the conclusion that the U.S. benefits when the hypothesis is true. An alternative conclusion could be drawn from the maintained hypothesis. First, the cost of capital in the latter period was substantially larger than in the former. This requires greater net revenues to cover the fixed costs. It is also possible, although not likely, that the exclusion of the foreign vessels drove up consumers' prices from imported seafood. If this were true, then there might be nothing more than a transfer of wealth from U.S. seafood consumers to U.S. producers, without any net gain to the United States.

This latter possibility raises a serious conceptual problem with the maintained hypothesis—how do consumers enter into the analysis. Whereas Conrad probably is reflecting accurately the philosophy and value judgments of the National Marine Fishereies Service, the hypothesis and analysis should also reflect consumer welfare. MFCMA would indeed be of little value to the United States if consumption remained the same, producers net revenues rose by $2 billion, and consumer expenditures rose by $4 billion. It is recognized that the data problems expand when the consumer is considered, but that is no reason to ignore entirely the conceptual issue.

The empirical analysis in this paper underscores the gap between economic theory and applied economics in fisheries. This gap was made obvious to me the other day when an agricultural economist asked me to cite a "seminal" applied work in fisheries. Every article which came to mind had serious flaws, mostly relating to data quality and availability. It is particularly troublesome when someone must use vessel costs, as with Conrad. At some point, NMFS should consider undertaking cost studies on a regular basis. Conrad derived costs in a naive but likely necessary fashion. However, it really detracts from my confidence in the results.

There are also some practical problems which must be raised. The analysis does not attempt to remove species which are not under the jurisdiction of MFCMA. Important species such as tuna or menhaden (which is under MFCMA jurisdiction but not managed) can strongly influence the results. The hope or assumption that changes in these extra-jurisdictional species offset one another may be unjustified. In fact, production from most of the extra-jurisdictional species familiar to me have declined over the period of analysis. This would suggest that Conrad's estimates of benefits are understated.

Whereas I likely agree with the conclusions of this paper, it is not because of the analysis. There are good deductive arguments to reach these conclusions, and their force is likely stronger than the evidence presented here. In fact, recent work by Norton, Miller, and Kenney (1985) reaches similar conclusions based on a better analysis, in my opinion. The paper might be stronger if it had accepted the Norton et al. (1985) conclusions and developed more completely some of its interesting thoughts on the development of transferable quota system under MFCMA.

Literature Cited

Norton, V. J., M. M. Miller, and E. Kenney. 1985. Indexing the Economic Health of the U.S. Fishing Industry's Harvesting Sector. U.S. Dep. Commer., NOAA Tech. Memor. NMFS-F/NEC-40.

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Bridging the Gap Between Economic Theory and Fisheries Management: Can the MFCMA Produce Economically Rational Management?

LEE G. ANDERSON

ABSTRACT—The paper analyzes the possibility and the probability of appropriate use of fundamental economic principles in the fishery management plans developed under the Magnuson Fishery Conservation and Management Act. After reviewing the resource, industry, and government aspects of the fishery management development process and some of the important aspects of both the existing law and suggested changes, it is concluded that while the possiblity exists, the probability is quite low.

Introduction

This paper addresses the question of whether the Magnuson Fishery Conservation and Management Act of 1976 (MFCMA) can produce "good" fishery management, "good" in this case meaning appropriate utilization of lessons to be learned from economic theory. The MFCMA outlines a philosphy and process for management of the nation's marine fishery resources. The Act also is the basis of the institutional structure for marine fisheries management.

National concerns about preservation, as well as accepted biological and economic theories, play an important role in fishery management decisions. What emerges from the decision-making process, however, is also influenced by institutional organization and structure. Of particular importance is the interaction between individuals in the structure, and the way these individuals perceive and carry out their respective roles.

The analysis will proceed as follows. The first section defines terms while the second presents a general analysis of what is meant by the fishery management institutional structure and describes how it interrelates with industry activity, and how this interplay determines the nature of actual fisheries operation. The next section describes the institutional structure set up by the MFCMA, giving special attention to the direct and indirect hindrances to good management it imposes. The fourth section discusses proposed changes in the system as put forth by Congressional amendments to the MFCMA and a report commissioned by the NOAA Administrator. The final section summarizes the general conclusions.

Before going on, however, it is important to stress that while I am somewhat critical of the MFCMA and the structure it imposes, this does not necessarily reflect on the individuals who work in the system. On the whole, they are working in a professional manner. Unfortunately, they are working in a system which sometimes encourages strategic behavior where what appears beneficial for one part or level of the system can be deleterious for the whole and which also, directly or indirectly, proscribes many useful approaches or actions.

Definitions

If this paper is to have any focus, it will be necessary to define what is meant by good management. Most biologist or economist fisheries professionals define good management as that which most closely meets a specified set of criteria. Economic criteria are concerned with the proper use of fish and other resources over time and focus on determining an intertemporal harvest plan wherein the correct amount is caught each year giving appropriate attention to all related costs including harvest, programmatic management, and implementation and enforcement costs. Biological criteria deal with sustainable yields and protecting the stocks against depletion. Other potential criteria include employment levels, cultural traditions, etc.

In practical applications, however, good management often is nothing more than something upon which all concerned can agree. Having a regime in place, regardless of its theoretical content or its potential for effective implementation, is sometimes seen as evidence of a successful management institution. In my view, this is hardly a satisfactory criteria for good management. Getting something in place can be a useful first step, but only if the step is in the right direction.

Because the emphasis of this symposium is on bridging the gap between economic theory and fishery management, I will use broadly defined economic criteria to define good management. I will consider the issues of can or will the gap between economic theory and practice be bridged under the MFCMA; I will not however, directly address the question of should the gap be bridged or at least narrowed, notwithstanding my predilection toward answering that question in the affirmative.

To anticipate the argument to follow, however, the MFCMA can be judged completely successful only by the more limited criteria of ability to getting something into place. Fishery management plans often are a compromise that the majority of interests can agree on, but sometimes they are regimes that politically astute or powerful minorities can push

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through the system to the dismay of the majority. Is it possible for this system to produce good management by my broadly defined economic criteria? Perhaps so, but a better question is "Is it likely that sound economically rational management will be produced?" My view is that the answer to the latter question is "probably no."

I base my pessimistic conclusion on the following analysis and also on my somewhat limited direct experience with the workings of the fisheries management system. I recently worked with others at the National Marine Fisheries Service (NMFS) in preparing a set of guidelines for regulatory analysis of fisheries management actions. The main goal of the guidelines was to insure that fishery managment plans (FMP's) gave appropriate consideration to all aspects, but especially the economic aspects, of the national standards (see below), and other regulatory directives. Although most people I talked to would unofficially agree that the structure and logic of the guidelines was quite good, there was less than enthusiastic support for their implementation. Because of the nature of the fishery management system, wherein the Councils and NMFS are sometimes adversaries, this attempt to introduce some basic economic principles into the management plan development process, was viewed by some as another attempt to make the work of the Councils more difficult and to put them even more firmly under the control of NMFS. Others question whether guidelines would be effective in a system that is so heavily influenced by political considerations.

The Importance of the Institutional Structure in Fisheries Management

Simply put, the purpose of fisheries management is to change or otherwise influence the behavior of commercial and recreational users of the resource. To understand fishery management it is necessary to understand how the various behavior patterns relate to the biology of the stock. However, a significant part of users' behavior is their interaction with the fisheries management agencies, and it will be just as necessary to understand this as well.

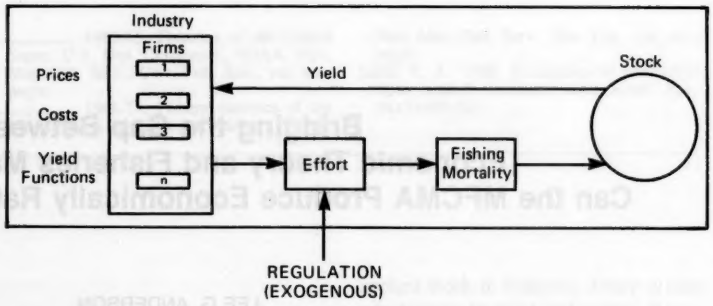

Figure 1.—The Bioeconomic Model: What kind of regulations should we have? Regulation is viewed as an exogenous variable which can control the amount of fishing effort so as to achieve various objectives.

Focusing on commercial fishing only to keep the discussion within bounds, consider first the harvesting industry aspects of fisheries utilization. This can be described by a bioeconomic model of a fishery (Fig. 1). In this model, the fishing industry is viewed as a collection of individual firms or boats which react to market prices, input cost, and the fisheries production function (i.e., the relation between fishing effort and catch) and produce fishing effort as long as it is to their financial advantage to do so. Profits are viewed as the driving force of the whole system. The search for profits and avoidance of losses determine the number and rate of change of the vessels and the amount of effort produced by each. Total effort, in combination with the size and the cohort distribution of the current fish stock, determines the annual yield and the condition of the stock in the next period.

Using the bioeconomic model with specific economic and biological assumptions, it is possible to construct detailed models which describe how fleet size and effort, and stock size and composition will vary over time. For example, under certain circumstances, it is possible to describe an open-access equilibrium where the stock will not change because harvest is just equal to natural growth, and where fleet size will not change because profits are sufficient to keep existing vessels operating but not high enough to attract new entrants (Anderson, 1986: Chapter 2). Due to the open-access nature of the industry, the unowned fish resources are suboptimally utilized in that the value of the marginal or last unit of fish caught in any period (VMO_F) is less than the value of the marginal foregone production necessary to produce fishing effort ($VMFP_E$) plus the marginal present value of changes in future production due to changes in the size of the existing fish stock. The latter is often referred to as the marginal user cost (MUC).

Looked at from a different angle, the optimizing condition for an economically efficient fishery in terms is:

$$VMO_F = VMFP_E + MUC. \qquad (1)$$

The critical reader will note that Fisheries Management Councils have never used condition (1) for an objective of any of their management plans. Perhaps this is a result of the incomplete information used by or made available to the decision makers. It is likely, however, that the decision makers have a fair understanding of the economic issues. It is just that other issues are more important.

To better understand what lies behind management decision, it is useful to expand the bioeconomic model by adding to it the institutional structure which develops fishery management and development policy. Elsewhere (Anderson, 1982a, 1984, In press) I have called this expanded analysis the political bioregunomics approach. A schematic of this approach is diagramed in Figure 2. By necessity, Figure 2 ignores many of the complexities of the issues involved. The

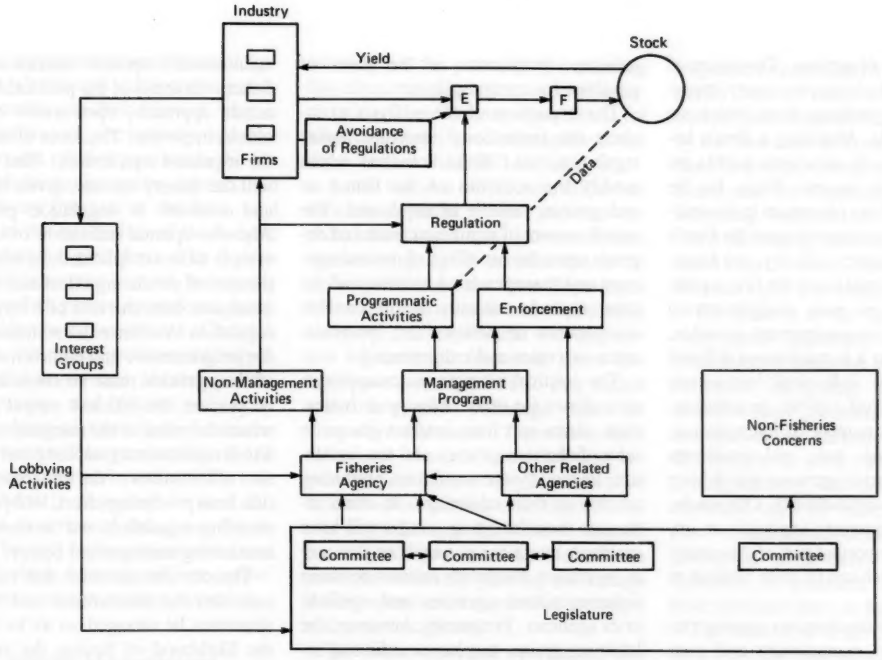

Figure 2.—The Political Bioregunomics Model: What kind of regulations are we likely to have? Regulation is viewed as a endogenous variable which is determined by the interactions of fishermen, politicians, bureaucrats, and other interest groups.

behavior of the fishing industry is still the driving force of the system, but in addition to price, cost, and yield, the individual firms also react to signals from various government agencies and, in some instances, even take steps to influence government activities or to moderate their effects. Government bureaus and regulatory agencies are also driving forces whose behavior must be understood. Indeed just as the bioeconomic approach considers the interactions of the fish stock and of the industry, the political bioregunomic approach looks at the three-way interaction between fish stocks, industry, and government entities.

At the top of the institutional structure is the legislature. It determines mandates, areas of influence, basic operational guidelines, and, perhaps most important of all, the budgets for the various agencies. Because fisheries matters are only a small part of the overall concern of legislatures, nonfisheries activities and agencies must be considered since they are a competitor for legislative time and budget allocations. For example, the legislature may choose not to allocate funds to a research program even if it can be shown that it would improve management, because in their opinion, there are other more important uses of the scarce government revenues.

While nonfishery concerns cannot be ignored, the main focus should be on those agencies which have direct or indirect effects on fisheries utilization. For any level of government, these can usually be divided into fisheries agency and other related agencies. In the United States, the latter group includes the State Department, which is concerned with the allocation of quotas to foreigners; parts of the Commerce Department such as the Small Business Administration which may grant loans to the fishermen; and the U.S. Coast Guard which has a large role in regulation enforcement.

An intermediate step between the legislature and the relevant agencies is the former's committee structure. Most important decisions are made in committees and the mandates and budgets given to the various agencies can depend on the favor each are given in various committees and sometimes on the particular attitudes of influential members of important committees. In addition, since more than one committee may deal with a particular agency, the interrelationships between committees is important. Also, the oversight responsibilities of certain committees can, when members so desire, have an important influence on the day-to-day activities of particular agencies (Weingast and Moran, 1983).

The fisheries agency is obviously an important part of the fisheries management institutional structure. Given the budgets, mandates, and constraints imposed by the legislature, its committees, and other related agencies, the fisheries agency, or more correctly, its directors and personnel, operate so as to achieve

their perceived objectives. The nature of these perceived objectives is very important but it is something about which we know very little. Modeling a firm's behavior is relatively easy since profits are a measure of its success. Since, for the most part, the long run return to the individual employee depends upon the firm's success, employees will, by and large, operate so as to maximize the firm's profits. There is no such straightforward "bottom line" in government agencies, however, and so it is much more difficult to predict how individual bureaucrats will operate (Wolf, 1979). In addition, there is often a number of international, Federal, regional, state, and sometimes even local fisheries agencies which have some management authority. Obviously, the way they interact (explicitly or implicitly) is an important part of this analysis, but one which can be quite difficult to understand.

The work of the fisheries agency can be divided into management and nonmanagement activities. Management activities are any programs directly related to the control of harvest to prevent overexploitation, however defined. Nonmanagement activities include fisheries development (i.e., marketing programs, loan programs, etc.), product quality, navigational safety, etc. Although the latter are not directly aimed at controlling harvest levels, they have an effect on the amount of effort that will be produced because they can affect prices and costs facing individual firms.

A management program can be thought of as the fixed component of fisheries policy. The agency can use total quotas, gear restrictions, taxes, individual quotas, etc., or some combination as its basic regulation tool. Once the tool is chosen, however, there are two variable components. Programmatic activities include the research and bureaucratic work necessary to determine how the governing instrument will be used. For example, the role of these activities is to determine the size of the quota, the nature of the specific gear restrictions, etc. The other variable component is enforcement or monitoring. The management program will have no effect on the behavior of the industry and hence, no effect on stock utilization unless there is an incentive for industry compliance in the form of penalties for noncompliance.

The expansion of the analysis to include the institutional structure makes regulation (i.e., those activities which modify the activities of the firms) an endogenous variable of the model. The actual amount of regulation produced depends upon the net effect of nonmanagement and management activities, and the latter depends critically on the variable components of policy (i.e., programmatic activities and enforcement).

The political bioregunomics approach also allows for other industry activities. First, firms can form interest groups to lobby fisheries agencies and the legislature to modify the regulation producing process to their advantage. In some instances these lobbying groups will have common interests, as would be the case in legislative budgetary debates between fisheries-related agencies and nonfisheries agencies. Frequently, however, the lobbying groups may have conflicting interests (i.e., inshore vs. offshore interests, etc.). In this regard, the industry must be expanded to include processors which can be motivated to lobby for both management and nonmanagement programs either in support of or in opposition to the interests of the harvesting sector. The relationship between the processing and the harvesting sectors is a topic that has received scant attention in the bioeconomic models, but it is obviously an important item in the understanding of how the management institutional structure actually works.

Individual firms may also find it to their advantage to engage in avoidance activities to reduce the effects of regulation (Anderson and Lee, 1986). If returns from using resources to evade regulations are greater than the expected costs, at least some firms will likely do so. This behavior is important for two reasons. First, the avoidance costs will be a waste of resources and second, it will affect the way regulation actually modifies fishing behavior.

An advantage of this broader approach to understanding fisheries utilization is the recognition of other types of management costs. The basic thrust of the bioeconomic approach is to compare the difference between the open access and the economically optimal utilization of the fishery. In terms of the political bioregunomic approach, open-access becomes almost irrelevant. The focus of interest is the regulated equilibrium. That is, how will the fishery operate, given the types and amounts of regulation produced. Also the optimal utilization of the fisheries is more complicated. In addition to the cost of producing effort and the marginal user cost, the cost of lobbying and regulation avoidance to the industry, and the programmatic and enforcement costs of the agencies must be considered. To be precise, the efficient output point is where the value of the marginal output of fish is equal to marginal user cost plus the sum of the values of the foregone production from producing effort, lobbying, and avoiding regulation and instituting and monitoring management policy.

The obvious question that follows is how can the institutional and industry structures be changed so as to increase the likelihood of having the regulated equilibrium coincide with the expanded version of optimal utilization. In addition, however, the question of what types of regulation are optimal must be reformulated to consider the effects of various regulations on those costs related to activities other than producing effort. For example, lobbying costs may be a function of the ease of access of lobbyists into the halls of power and the flexibility given to individual administrators. If there is little flexibility, the returns to lobbying will be low and hence lobbying expenses will be low. High flexibility programs, on the other hand, may encourage lobbying. Similarly, certain programs may be easier to enforce than others and hence monitoring costs will be lower, and avoidance costs may be lower as well because the returns to evasion will be low.

Using the political bioregunomic approach to view the system as a whole, the actors interact as follows. The firms produce output so as to maximize profits subject to the constraints of market prices, costs, fish availability, nonmanagement government intervention, and the type and enforcement level of management regulations. They also form groups to lobby the fishery agency and legislature. The agency (or agencies)

produce management and nonmanagement regulation and enforcement activities, according to their view of what is good for the stock, the industry, and their absolute and relative position in the bureaucratic hierarchy, taking into account the lobbying pressure of the firms, and subject to the constraints of the budgets and operational guidelines. The legislature determines the size of the agency budget and its general operational guidelines subject to the constraints of the constitution, the overall government budget, the relative importance of other government activities, and political realities.

To understand what kind of fisheries management will be produced by the institutional structure set up by the MFCMA, it is necessary to view this structure in terms of the above framework. This will be the subject of the next section, which draws heavily on a previous work of the author (Anderson, 1982b).

Current Management Institutions Under MFCMA

The main purpose of the MFCMA can be summarized by the National Standards found in the act:

> Conservation and management measures shall prevent over-fishing while achieving, on a continuing basis, the optimum yield. . . .The term "optimum" with respect to the yield from any fishery means the amount of fish—(A) which will provide the greatest overall benefit to the nation with particular reference to food production and recreational opportunities and (B) which is prescribed as such on the basis of maximum sustainable yield from such fishery as modified by any relevant economic, social, or ecological factor.
>
> Conservation and management measures shall, where practicable, promote efficiency in the utilization of fishery resources except that no such measure shall have economic allocation as its sole purpose.
>
> Conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplications.
>
> To the extent practical . . . interrelated stocks of fish shall be managed as a unit or in close coordination.

The first two of these national standards appears to establish economic efficiency as an important objective of fisheries management in the United States. However, the phrase "where practicable" certainly has the potential of weakening this objective, depending upon its interpretation. Therefore, my rigid criteria for what constitutes good management has some basis in the MFCMA itself.

As the law was written, the difference between "optimal yield" and the expected domestic annual harvest of each species or group of species was to be made available by the State Department to foreign nations who had traditionally harvested that species and who met certain requirements. However, these foreign boats were required to pay certain vessel fees, and "poundage" taxes on their allowable catch. There have been subsequent changes in the law that require domestic processing capacity to be utilized before turning to foreign processors (regardless of the relative costs of the two) and provisions have also been made for eventually phasing out foreign fishing when there are specified increases in domestic capacity.

The most important operational elements of the MFCMA are the eight regional Fisheries Management Councils, which prepare management plans specifying how much of each species will be caught and determining, directly or indirectly, by whom.

Each Council has the responsibility of managing the species within its geographical area, but where species are important in two or more areas, they are jointly managed by the respective Councils, although one may be designated as the lead Council. While they are important, the Councils are only one part of a complex management system set up by the MFCMA, which also includes the National Marine Fisheries Service, the Departments of Commerce and State, and the U.S. Coast Guard. The role of each of these other agencies, and a description of how they interact with each other and with the Councils will be discussed below. For the moment, we will focus on the role of the Councils.

About half of the Council members are the secretaries for natural resources (or the equivalent) in the states in the particular region, along with the regional director of the National Marine Fisheries Service of the Commerce Department's National Oceanic and Atmospheric Administration. The other half are "knowledgeable or experienced members of the public" who are nominated by the governors of each member state and selected by the Secretary of Commerce. In addition, individuals from the U.S. Coast Guard and the Department of State are nonvoting members of the Councils. Since the number of states in each region is not equal, Council membership varies between eight and sixteen people.

The makeup of the Councils is obviously quite important in determining what kinds of plans are developed. It is, therefore, interesting that the public members have predominantly been representatives of harvesters, processors, distributors, or some other aspect of the fishing industry. Individuals who might represent other or more general interests—consumer advocates, professional biologists, economists, or recreational fisheries, or planners, for example—have certainly been in the minority.

The main work of the Councils is done by a full-time professional staff consisting of an executive director and others with training in biology, law, planning, and economics. The Councils usually meet every 4-6 weeks for 2-3 days, under the direction of a chairperson elected from their midst, to review and approve the work done by the staff, to discuss future activities, and to vote on policy issues.

Each Council has a Scientific and Statistical Committee, a voluntary organization, composed of academic and government fisheries management scientists including biologists, economists, sociologists and anthropologists, and planners. The purpose of this committee is to provide technical advice. In addition, they can have voluntary industry advisory boards comprised of industry participants to provide practical advice on how various regulations will affect them, both as a unit and each component part.

Although each Council has the same organizational structure, they often differ widely in the way they operate. For example, Councils have in the past issued contracts to consulting firms or universities to write the plans. Others set up special task forces consisting of Council members, scientific and statistical committee members, industry representatives, and NMFS and Council staff peo-

ple to write the plan. In some Councils the staff has primary responsibility for writing plans. Finally, some Councils actually write important sections of their plans during regular Council meetings. The result is that the plans prepared by the Councils have sometimes been quite different.

However it is developed, each fishery management plan must be discussed in open public meetings and must be published in the *Federal Register*. The Council must respond in writing to any written comments that result, and often does so in an appendix to the final plan. It should come as no surprise that these comments come almost exclusively from representatives of the industry. Industry people have more to gain from the costs of preparing such formal comments, since a specific proposal could significantly affect their profits. By contrast, isolated individuals may gain very little from advocating economic efficiency even though the gains to the whole economy are quite large.

After the public hearing process, the plan must be approved, technically, by the Secretary of Commerce, but for all practical purposes, by the National Marine Fisheries Service. Before going back and discussing the plan preparation process in more detail, it will prove useful to explain exactly how NMFS and other agencies fit into the system.

The National Marine Fisheries Service has a double role. First it is the source of most of the biological and economic information used to produce the plans. This has sometimes been a source of conflict for a number of reasons. The Councils complain that they are not provided with the right types of data in a manner in which it can be of direct use. NMFS responds that they are providing the best data they can, given the state of biological and economic research, and of their existing personnel and budget constraints and the other research tasks they are obligated to perform. Sometimes when scientific biological data is apparently at odds with industry observation, there is pressure on NMFS to reassess their stand. When the Councils try to increase their biological staffs, it is sometimes viewed by NMFS, at worst, as a way to either bend the data, or at best, as a way to take over some of the responsibility which they believe rightfully belongs to them.

The other role for NMFS is to approve the plans prepared by the Councils. As can be imagined this causes a considerable amount of friction between two organizations. In some instances understanding the institutional aspects of the approval process is even more difficult than it appears on the surface because of the presence of other players who are not actually on the formal program. The staffs of the NMFS regional and research center offices often work quite closely with Councils and Council staffs in the preparation of management plans. Indeed the Regional Director is a member of all of the Councils in his area. Because of this familiarity with the details of all the issues, and quite frankly, with the personality and preferences of the Council members, staff members, and industry representatives as well, there is a certain amount of internal pressure for approval by the National Office of NMFS from its field offices. When approval doesn't come, the Council and industry see NMFS as an agency with different conflicting points of view.

Another important player in the management development process is the Congress of the United States. Admittedly, its most visible role in the whole system, now that the law is in place, is to allocate annual budgets. However, the MFCMA has been amended many times in its 10 year life and has been going through an extensive Congressional review as part of the 10 year reauthorization process. In addition to these efforts with respect to the framework of the system, Congress sometimes also has some direct input in the plan approval process. As a plan is developed at the Council level and then forwarded to the latter for approval, individuals who will be hurt by the specific regulations, or who would be better off under different regulations, have plenty of time to see their relative positions under different types of schemes and to make their view known. (In fact, it may be argued that such access is too freely available.) However, the incentives to change the plan do not halt with final approval or disapproval from NMFS. Industry representatives have been known to go directly to their legislators if the approval process has gone or appears to be going the wrong way. It is not possible to cite specific examples, for obvious reasons, but occurrences are such common subjects of complaint at many fisheries management conferences (e.g., Frady, 1985) that even if they don't occur (which is highly unlikely) the very fact that they are perceived to occur has an effect on the operations of other parts of the system.

The states are also another important part of the system. Since they have control of fisheries out to 3 miles, their cooperation on stocks that can be harvested on both sides of that line is crucial. If they do not work closely on such things as enforcement and data collection, the chances of good management are quite small. There is a feeling, however, especially in the Gulf states, that the states can do a better job independent from the cumbersome Council system. This obviously has an effect on the way they will work with the Council system because if it fails, the revised system may give them full control.

Fisheries management plans are enforced jointly by a branch of the National Marine Fisheries Service and U.S. Coast Guard. Since the latter has many other responsibilities, an important part of producing good management is inducing the Coast Guard to act in a coordinated way with NMFS and not allow emphasis on other activities to crowd out the time required for at-sea enforcement.

While these paragraphs can only provide a brief outline of some of the nuances of the entire system, it should be obvious that the institutional structure is a complex one indeed, and as will be seen below, these complexities will have implications of the types of policies that will actually be produced.

Returning now to the actual operation of the Councils, each one has the responsibility of preparing annual, biennial, or even permanent framework plans for the species under its control. Even after 10 years, none of the Councils have completed plans for all the species under their jurisdictions. The workload of the Councils is substantial and all are revising their existing plans and developing others.

On the surface, most Councils use the

following procedure for developing fishery management plans. First, the objectives for management are determined. Within the constraints set by the National Standards and various operational guidelines produced by the National Marine Fisheries Service, the Councils can choose any objective they feel appropriate for the fishery involved and the particular problems it faces. The real problem is specifying objectives that have operational significance (a goal to "improve the fishery" is not of much use in choosing among specific management techniques). If there are conflicting objectives, the Council must place relative weights on them so appropriate tradeoffs can be made.

The next step is to identify a set of alternative plans which will specify optimal yield and identify how the harvest will be limited to that level. Finally, the plan which most nearly achieves the stated objectives is selected. If the objectives are reasonable, if the range of alternatives considered is broad and imaginative, and if the analysis used to compare the alternative plans and the objectives is correctly done, a suitable management plan will result.

In all fairness to the Councils, it must be noted that while the above procedure is easy enough to explain, it is often most difficult to apply in practice. There is often a lack of critical data (in some instances there are no data at all), and even where it exists, budget, time, and manpower constraints make it very difficult to perform the above procedure in a perfect way.

In reality, of course, the system does not operate this straightforwardly. One sometimes gets the feeling that a particular plan is chosen in advance and that the desired yield, objectives, and other components are then selected to ensure that the favored alternative emerges victorious. This is especially true when the pursuit of one objective—say efficiency—might impose job losses or other distributional problems on certain parts of the fleet. With respect to the tradeoff between economic efficiency and distributional issues, the latter implicitly appear to be more important, as one would expect given the influence of industry representatives in the planning process.

Another reason why the above procedure is not followed as rigorously as need be is the bureaucratic motivation of the main agencies in the management system. For instance, one reason for rejecting an economic efficiency objective is that according to the MFCMA and NMFS procedures, a main criterion for plan approval is how well the selected management policy achieves the stated objectives. Therefore, why include an efficiency objective when it can be difficult to judge different options against it? The business of the Council is to produce plans and thus they are loath to do something that will make their job more difficult.

Also, since it is industry that is most likely to protest, there is a tendency for the plans to be written so as to minimize potential complaints, lawsuits, and other procedures that can make the work of the Councils more burdensome and increase the probability of a negative review from NMFS. Therefore, economic efficiency and other important management issues which are of little concern to those likely to complain may not receive appropriate consideration.

On the other hand, NMFS appears to have taken the position that as long as the plans meet the stated objectives and unless they blatantly violate one of the National Standards, the plan will be approved. It is unlikely that a plan will be disapproved on grounds of inadequate objectives. NMFS too is in the business of producing plans and they do not want to stand in the way of implementation, especially over issues concerning income distribution or other politically sensitive topics. This is an important point. Secretarial approval of plans does provide the opportunity for consistency and also can ensure that purely regional interests do not prevail in fisheries policy. If, in fact, the review system is lax in this regard, some of the potential benefits of the MFCMA will be lost.

While NMFS has been reluctant to refuse approval because of inadequate consideration of efficiency, it frequently disapproves plans because of procedural issues. This has created animosity between the Councils and NMFS, with the former sometimes accusing the latter of trying to regain some of the preeminence it lost with the passage of the MFCMA. NMFS counters such arguments by emphasizing that rejections on procedural grounds are appropriate because they will prevent potential lawsuits. This ill will can certainly affect the smooth operation of the system. In addition, these rejections have caused the Councils to be even more concerned with the necessity of preparing plans that will be approved and hence they are less willing to look at economic efficiency matters.

For someone not familiar with the MFCMA, the above discussion is probably very bewildering. The process of developing fisheries management in the United States is very complex, and it is very difficult to describe the formal chains of command and to provide a feel for the informal structure that is built around it. On the other hand, individuals who have worked closely with the system may feel that the picture is far from complete. As bewildering as the described system may appear, the reality is often another step beyond.

To some degree, my failure to capture all of the system was a matter of choice. I felt the constraints of space and therefore only covered the more prominent parts of the system. However, some of the failure was due to a lack of complete information. I make no claim to knowing all there is to know about the system. One would have to work full time at all levels in order to obtain such expertise. Further, since each of the Councils act differently within a different set of state governments trying to manage species of different types and different biological and economic complexities, knowing how the system works within one Council or on one coast, would not necessarily mean knowing how things work elsewhere. However, while the discussion may not have provided a complete and general analysis of the way things work, I believe it does describe the rudiments of the operation and provide a feel for the complexities involved.

To summarize, the fisheries management institutional structure as set up by the MFCMA, the operational guidelines, and formal and informal standard operating procedures is not very conducive to introducing economic efficiency reasoning into management plans. There are too

many places where individuals, groups, or agencies can step in and stop, slow down, or reroute the process if it does not appear to be producing results favorable to a particular point of view. Many can hinder progress, but no one is held accountable for not achieving it. A process that has so many bosses that no one is really in charge is almost certainly doomed to failure. On the other hand, a juggernaut which rammed things through giving no attention to divergent views would be also unlikely to prove successful. To correct these faults, it will be necessary to assign accountability for success to a single source, while at the same time granting it sufficient latitude and resources to do the job. It will also be necessary to maintain public review and comment procedures to insure that all views and positions can be utilized in making the final decision.

Proposed Changes in the System

The 10-Year Reauthorization

As part of the 10 year reauthorization of the MFCMA, there are numerous suggested changes to the act which have appeared as formal legislation to amend the act. In addition, a "Blue Ribbon Panel" appointed by the Administrator of NOAA has just released a report on ways to improve the management system set up by the MFCMA. The purpose of this section will be to evaluate these proposed changes in terms of their ability to improve the likelihood of the system to produce good management.

Some of the proposed changes contained in the legislation now before Congress can have significant effects on the way the whole system works. Rather than discuss each of the specific bills, the analysis will focus, instead, on specific changes, some of which are found in more than one bill.

Several of the amendments directly address the interests and the qualifications of prospective Council members. One changes the qualification criteria from "knowledgeable or experienced" to "knowledgeable and experienced" and in addition requires that members provide a written statement of their current financial interests in the commercial and recreational sector of the fishing industry which will be made available to the public at each Council meeting. Another requires that when making Council appointments, it shall be necessary to "ensure a fair apportionment, on a rotating or other basis, of the active participants (or their representatives) involved in the fisheries under Council jurisdiction." Another would require a representative number of commercial and recreational fishermen including at least one practicing commercial fisherman.

In an early critique of the make up of Councils, Pontecorvo (1977) provided the following quote from Adam Smith (1776:128).

> "People of the same trade seldom meet together, even for merriment and diversion, but the conversation ends in a conspiracy against the public, or in some contrivance to raise prices. It is impossible indeed to prevent such meetings, by any law which either could be executed, or would be consistent with liberty and justice. But though the law cannot hinder people of the same trade from sometimes assembling together, it ought to do nothing to facilitate such assemblies much less to render them necessary."

It is useful to interpret the motivation behind the above amendments in the framework of this quote, although there are, admittedly, other relevant issues here as well. The MFCMA does more than bring people from the same trade together, it gives them significant power in determining how the industry will be operated. There is a delicate balance here, however. Successful management requires extensive amounts of data, a great deal of which can be most easily supplied by industry participants, as well as, at least, the begrudged consent of those being regulated. Therefore there are good reasons for industry to have, at least, a strong advisory role, and given the nature of the whole system, some minimum number of voting members on the council.

As indicated above, my view is that one of the weaknesses of the present law is the strength of the overall industry interest group. The goal of most of the above changes, however, would be to increase that strength. Making knowledgeability and experience a requirement for Council membership sounds fine at the surface, but if experience is interpreted to be experience in the industry, it will prevent academics, and those with recreational and consumer expertise from participating. Further, while the financial disclosure requirement may provide some relief against votes that are clearly in one's own business interest, there are no proscriptions against potential conflict of interest voting.

Although there is definitely a pro-industry flavor to these suggestions, many of them may have evolved from intra-industry conflicts, both recreational vs. commercial sectors, as well as between different parts of the commercial fishery. Each wants to insure that their interests are adequately represented.

In general then, there is little hope that these particular changes will improve the system. In one sense they may be viewed as another round of interest group bickering, although at a higher level, that has already been identified as an endemic failure of the system. If the system was focused on issues of real concern to actual management, we would not have to waste time on these points, but given what the system is, it is not hard to see why participants are pressing these issues rather hard. However, there is little hope that strengthening the absolute power of industry on the Councils will do anything other than focus even more attention on distributional issues rather than on the hard but necessary choices of how to restrict effort on overutilized resources. The suggestion of rotating industry sector representation on the Council may be useful in preventing over-representation of particular interests, but it is flawed because it legitimizes bickering over distributional gains.

Other parts of the proposed amendments address the conflict between foreign and domestic utilization of the fish stocks of our shores. The current batch of amendments is a continuation of a trend in past changes in the MFCMA to phase out all aspects of foreign fishing and to develop a 100 percent U.S. harvesting and processing industry. This is a more difficult issue to evaluate, and there are at least two aspects that should be considered. First, there is the overall economic

rationale for complete domestic utilization. Second, there is the potential effect of too much attention being paid to who catches the fish as opposed to other more important management issues.

From an economic efficiency point of view, there are reasons to question a pure domestic industry policy. If U.S. harvesters and processors really have a comparative advantage in utilizing the fish in the conservation zone, the most they would require is a short period of protection in which to learn the most suitable techniques and to gain access to the appropriate markets. Forcing the foreigners out when they are more efficient harvesters or processors could be to the long-run detriment of the general U.S. economy. In that situation it would be better to charge the foreigners an appropriate market price for access to our zone and then use our labor and capital resources where they can be more productive. The U.S. economy would then have foreign exchange with which to import goods and services, and the value of the production of our own resources.

With respect to the second issue, note that every regulation program has distributional aspects. Quotas sometimes benefit those parts of the fleet which are able to get out early in the season, gear restrictions place a significant relative disadvantage on those individuals who are skilled in the prohibited activities. As such there will be built-in support and opposition factions for most regulations. The potential for disagreement will hinder the approval and implementation of such regulations. However, the "Americanization" policy brings the distribution issues straight to the surface and makes them part and parcel of the plan development process. Therefore, a difficult problem is made even harder. This is especially the case since Americanization of processing can hurt domestic harvesting by shutting off a potential range of buyers and hence lowering aggregate demand for their product. The fisheries plan development process is restricted in the types of things it can do, and some of the things it must do will have a tendency to cause dissension among parts of the industry. In a very real sense then, by the very nature of the law, the focus of management, from the top to the bottom of the system, will be shifted, more than it would otherwise, from the real issue of controlling effort to the distributional question of whose effort will be controlled.

Several of the proposed amendments deal with the prospects of implementing limited entry or limited access programs. One would change the law so that specific fees could be levied over and above the actual cost of operating the management program and further that these monies could be used to set up a dislocation compensation fund. The purpose of the fund would be to compensate fishermen for the loss or reduction of livelihood that may result from the implementation of limited entry program. This would obviously increase the chances of such regulation because it would reduce political opposition by potential losers.

Another proposed change would prohibit the implementation of limited entry programs (something that has been possible under the law since its inception) unless it was approved by not less than three-fourths of the voting members of the Council and by at least two-thirds of the fishermen presently participating in that fishery. This would obviously decrease the probability of passage. No other type of regulation or Council action requires such strict stipulations where such a small minority can prevent action.

A final change would prohibit the sale of any permits, shares, or rights granted to fishermen under a limited access system. Since transferability is crucial to achieving the full advantages of individual transferable quota or similar limited entry program, this change will obviously negatively impact on the ability of the MFCMA to achieve good economic management.

On the whole, if all three of these changes are accepted, the probability of bridging the gap between solid economic theory and practical fisheries management will have been reduced. The vote provisions will likely overpower the potential for the compensation fund, and the prohibition on transferability would drastically reduce the usefulness of any limited entry program that did get approved. On the other hand if only the tax and compensation fund provision is passed, the gap will have been narrowed.

NOAA Fishery Management Study

Several months ago the NOAA Administrator commissioned an extensive "Blue Ribbon Panel" study on the workings of the fisheries management system in the United States, and the first report was issued on 30 June 1986 (NOAA, 1986). One of the panel's objectives was to evaluate existing and potential institutional arrangements and management strategies according to their ability to best achieve the goals of marine fisheries management. Although the introductory prose in the report gives little or no attention to the economic aspects of fisheries management per se, the panel does state that a goal of their effort is to achieve management which is as responsible, effective, efficient, and economical as possible. They make many specific recommendations as to how to improve the system and it will prove useful to discuss many of them in detail.

The dominant theme of the entire report is the need to make a clear separation between what it calls "conservation" and "allocation" decisions. According to the report, conservation decisions are meant to maintain resource productivity for future generations, while allocation decisions basically distribute the opportunity to participate in a fishery. The panel argues that when these decisions are made simultaneously, there is a tendency to focus too much on allocation as a result of industry pressure to keep current catch levels high. As a result, conservation issues are put aside or ignored, and the stocks are often placed in danger.

As a solution, the panel recommends that NOAA, through the auspices of the National Marine Fisheries Service, set an "allowable biological catch" (ABC) for each fishery in the country based on the best scientific information currently available. These catch levels would be inviolable for the period for which they are established. The role of the Councils, according to the panel, would be to prepare management measures to allocate a harvest level equal to or less than the ABC among potential participants in the fishery.

While the basic point about pressures from the allocation decision having a ten-

dency to push conservation issues aside is only too true, the separation of the two decisions is not as neat as the panel might have one believe. In making such a sharp distinction, the panel ignores many biological, economic, and political aspects of management. Dichotomizing all of fisheries management into conservation and allocation is a gross simplification that could lead to serious problems in the construction and implementation of fishery management plans, and more importantly in the optimal utilization of the stocks for which they are designed.

In the first place, the conservation question (i.e., how much should be harvested this year and how much should be left to grow and reproduce) has economic and social components as well as the obvious biological one. The economic literature is replete with many theoretical and empirical articles on the optimal use through time of both nonrenewable and renewable resources (Clark, 1976; Fisher, 1981). With respect to renewable resources, the optimal harvest path is a function of the value in use through time, harvesting and processing cost through time, the discount rate, and the size and net growth rate of the stock through time. Therefore, the determination of how much to catch in the next few periods is considerably more complicated than a biological calculation of how much can be safely harvested. Since who does the harvesting (i.e., the solution to the allocation decision) affects the value in use and harvesting and processing costs, the link between conservation (how much should be harvested each year) and allocation is quite clear.

The joint relationship between what the panel calls conservation and allocation can be purely economic, purely biological, or some combination of the two. Consider first a pure economic interrelationship. Whether to catch more this year or postpone harvest until next year is, in part, determined by the relative values of the harvest in the different time periods. To take an extreme case, if the decision to harvest now is based on a high value fresh home consumption use but the allocation decision puts harvesting in the industrial sector, then the rationale for present use may be lost. The value of current catch in that use is less than can be obtained from postponing the harvest.

There can be a joint biological relationship because of differences in by-catch rates. If the decision to harvest 100 tons of X and 50 tons of Y is based on a low by-catch rate of Y with X using one type of gear, but the allocation decision allows most of the harvest by another gear with a higher by-catch rate, the ABC of species Y will be surpassed. Although these examples are quite simple, they demonstrate the point quite clearly. The conservation and allocation decisions simply cannot be separated.

Even if one ignores the fundamental link between the two questions, the problems of biological variability and determining the desired rate of the change in stock size raise other important issues with this artificial dichotomy. Expecting biologists to come up with a single number for an ABC is, quite simply, asking for more than they have, or are likely to have, the capability to do. Even if the goal is to keep a constant stock, given the uncertain knowledge of recruitment, natural mortality, and individual growth, and how catch and discards can be translated into fishing mortality, the best that can be done will be to produce a range of catches that will likely not change stock size. In some cases, it may be possible to estimate a probability of success to each catch size in the range.

If this is the best that can be done from a biological point of view, then perhaps the Councils should be given more than just allocative authority. With these uncertainties, there is a trade-off between harvest level and success in maintaining stock size. Further, since resolving it involves the range of social, economic, and cultural aspects of management, one might argue that the Councils are the proper place to address it. Let NMFS prepare the range and then let the Councils decide where along it the actual allowable harvest should be. The council can take the assigned probabilities of success into account so as to have a basis for trading off a lowered probability of maintaining the stock size next year and the probable extent of the potential error against the benefits from increased harvest this year.

The issue is even more complex when it is clear that increases in stock size are necessary or desirable. There will certainly be some trade-offs between the rate at which the stock is augmented and the achievement of other important fishery management objectives. It is hard to see how a decision on these trade-offs can easily be made in terms of the conservation and allocation dichotomy. One way to get around the problem would be to let the Council specify the growth path it desires and then NMFS can provide an estimate of the range of catch limits and associated success probabilities that will likely achieve that path.

The panel has identified a significant problem that occurs all too often in both national and international management organizations the world over, the Fishery Management Councils being no exception. Allocation issues can become so pervasive that conservation issues are pushed to the background. However, for the reasons discussed above, the suggested cure may be worse than the problem itself. Perhaps a better way to solve it would be to take a broader vision of what is really involved in producing good management. The panel seems to think that the essence of management can be stated in terms of two questions: 1) How much should be caught? and 2) Who should catch it?

Using this view and their suggested separation of authority, each Council is transformed into little more than a harried referee in a "battle royal" of all potential harvesters. Their chances of success are probably about the same as a single referee in a free-for-all with ten professional wrestlers. To be fair to the panel, I'm sure they envision a more significant role for the Councils, but with the emphasis on allocation, it is sometimes difficult to discern just what that role is expected to be. I strongly suspect, however, that the original authors of the MFCMA and the current members of the U.S. Congress expect more from the Councils than merely acting as organizations with the authority to cut up the fisheries pie.

I would propose a slightly modified version of the essence of management. Instead of two, I would use the following three questions: 1) How much should be caught? 2) How should it be caught? and 3) Who should catch it?

Because the National Standards man-

date efficiency in the utilization of fishery resources, the second question must be an integral part of a fisheries management plan. The Council must give consideration to the cost of harvesting fish, and, where practicable, give precedence to more efficient means of harvest.

Using a strictly economic point of view, the answer to these three questions are simultaneously determined by the solution of the economically efficient harvest time path. But given the difficulty of determining that solution, and in the interest of solving real-world fisheries management problems, including the one posed by NOAA's Blue Ribbon Panel, they can easily and quite rationally be looked at sequentially.

Once an ABC is specified, it is then necessary to determine with what gear, at what location, and at what time the fish should be harvested. Given the emphasis in the National Standards, consideration must be given to that harvesting approach that will produce that overall harvest as efficiently as possible, taking implementation and enforcement costs into account. Unless all industry participants use the same gear and can operate in an identical manner, the question of how the ABC should be caught will provide some preliminary answers to, or at least some important information on, the question of "who should catch it?".

If the Council feels that the allocation aspects of an economically efficient harvest plan are clearly inequitable and will likely produce long term injustices which cannot be compensated by other means, a more direct attack on the question of "who should catch it" will be necessary. Using the three questions as the basis for management will definitely put the allocation issue prominently on the Council's agenda, but it will also focus attention on other important issues of more national interest. This is in contrast to the panel's view of the Council's primary role as an arbitrator of parochial interests.

If the U.S. Congress and NOAA are determined to follow the panel's recommendation of a "separation of powers", it should be modified in the following way. NOAA and NMFS could still be given the responsibility of determining the ABC's for each fishery, but the expected response would be the range of catches and the associated probabilities discussed above. The determination of this range would be a joint biological and economic solution, taking into account the stochasticity of the mortality, catch, and recruitment characteristics of the stocks, expected output prices in various uses, expected harvesting and processing costs, the discount rate, as well as any objectives concerning stock growth rates provided by the Council. NMFS should be required to provide the range of catch limits for the next year, and, as an aid in long-term planning, for as many years into the future as existing data will allow.

The role of the Councils would be to: 1) Set the broad overall recovery plans for depleted stocks as an input into the work of NMFS in determining the ABC's (recovery plans that are significantly different from the economically optimal stock growth plan could be justified on some other grounds) and 2) determine the exact level of catch from the range provided by NMFS and how that harvest should be obtained.

Important issues for the first role are the rate at which depleted stocks can potentially be revived given their biological characteristics and the social and economic benefits and costs of the different paths to recovery. The important issues for the second role can be summarized in two questions: 1) Given the range of potential ABC's and the relative values of their probabilities of success, what is the appropriate trade off between extra catch today and success in achieving the stock recovery goals? and 2) What is the most effective and equitable way of obtaining a harvest less than or equal to specified ABC, taking into account harvesting, plan implementation and enforcement costs, and the financial and social effects on those who are, and are not, allowed to participate in the industry?

Both of these roles are obviously related to the biological attributes of the stocks, but they also involve economic, social and cultural issues, and as such, should be given to the Councils rather than to NMFS. The allocation issue is certainly a big part of the Councils' role, but it is not their entire reason for being.

The NOAA panel also had some strong words about the Secretarial review process. It recommended that review be limited to only the data, views, and comments which have been made a part of the official record, and be confined to the issue of consistency with the National Standards and other applicable law. The justification for this recommendation is the perception that the Secretary also reviews the policy judgments of the Councils. The speed and nature of the review process has been a source of contention since the inception of the MFCMA and, although not mentioned in the previous section, many of the current proposed amendments also deal with this controversial issue. Also, many of the amendments that have been passed since 1977 have tried, with varying degrees of success, to clarify and simplify the review process.

While it may be unpopular to argue for more power at the Federal level, in my opinion, the panel's appeals for a more restricted review process should be evaluated with care. Certainly an overburdening process can be costly and counterproductive to good, flexible fisheries management, but it is clear that there needs to be significant power at the top to insure appropriate consistency among the Councils (not that all Councils should have identical operations by any means) and to protect national resources against the somewhat parochial interests of the Councils. Therefore, any effort to restrict the Secretary's authority to review overall policy may place a severe limitation on the ability of the MFCMA to achieve good management.

There may be a problem with semantics here, however. If one reads the National Standards and Executive Order 12291 carefully, it is clear that plans are mandated to have a considerable amount of economic content in objectives, analysis, and the construction of the management regime. If the councils do not follow these mandates, the plans they produce should be subject to Secretarial disapproval. If this is what the panel meant by confining the review to issues of consistency with other applicable law, then I fully support their recommendation. However, I believe the panel, and certainly many others, would require a much less severe test of consistency, especially with the economic issues of Executive Order 12291. Some of the issues

that I would say are mandated by that Order, others may interpret as unnecessary interference in the policy making powers of the Councils.

The panel also recommended changing the way Council members are appointed. Instead of having governors from the various states make the nominations, the panel would allow any interested party within the geographical boundary of a particular Council to make a nomination. Then a nine-member national review board would review the background and experience of all nominees and present a list of the three best qualified individuals for each position to be filled to the Secretary. The purpose of the change would be to reduce the likelihood of purely political and hence less than qualified appointees.

As should be obvious from the first two sections of this paper, the make up of the Councils is critically important to the operation of the whole system. Therefore, the manner in which they are selected is a very serious issue. The proposed change would likely increase the number and range of interests of the individuals who would be considered for nomination, although there is nothing to prevent anyone from making suggestions to the governors under the existing arrangement. In one sense, of course, the change will only be moving the politicization back one step in the decision making process. The slate of nominees put forward will depend upon the makeup of the review board. The recommendation stresses that the board have broad geographic and user representation. Because of the problem of industry members regulating themselves discussed above, it is important that both the review board and the Councils themselves contain a balance of knowledgeable nonindustry individuals such as academics, recreational users, and consumers, as well.

The NOAA panel also makes two other recommendations related to subjects already covered in the discussion of amendments. First it recommends that any impediments to the implementation of limited entry be removed from the MFCMA and that Councils should seriously consider it as a management tool. This suggestion, if accepted, would obviously increase the chances of the MFCMA producing economically rational management.

They also recommend eliminating all barriers to full domestic utilization of all fisheries under MFCMA jurisdiction. They feel that by removing such impediments such as trade barriers, restrictions on the type of vessels that can be used, etc., the U.S. fishing industry can legitimately and successfully compete with foreign fishermen on the market. Stated in these terms, this argument certainly makes economic sense.

Conclusions

Can the MFCMA, in its present form or with some of the proposed modifications, produce good (as defined in this paper) management? The answer to the question, phrased as it is, must be a qualified "yes." If individuals up and down the institutional structure wanted to include economic analysis and conclusions in the construction, implementation, and enforcement of management plans, for all practical purposes they could do so. There are some restrictions, such as the current limits on implementing fees, but they are not generally fatal. While they may preclude certain options, others, which are relatively good substitutes, are permissable. In addition, some of the proposed changes would remove or weaken these restrictions, and so they may be even less of a problem in the future.

Will the MFCMA, in its present form or with some of the proposed modifications, produce good (as defined in this paper) management? The answer to this question is "probably not." The reason for this pessimistic reply is that while the institutional structure will permit the development of good management, it has so much flexibility that it cannot guarantee the same.

There are two ways to bridge the gap between economic theory and practical fisheries management. First, all, or at least a significant proportion, of the critical participants must be convinced of the necessity of introducing rational economics into the system. Second, some of the flexibility in the system must be replaced with binding guidelines which can insure that economic principles receive appropriate attention and are properly balanced with biological, social, and political considerations.

There is some hope for the first of these. Meeting such as this at the American Fisheries Society, and the growing importance and increasing amount of economic analysis in NMFS and Council activities are important steps in improving the overall economic literacy throughout the system. But, quite frankly, there are still many participants who have little or no understanding of the important economic concepts dealing with determining catch levels and the regulations to achieve them. As long as this is the case, the system will not give appropriate attention to economics.

On the other hand, there are many in the system who understand economic efficiency issues only too well, but for political or social reasons, choose to ignore them. A Congressman with an important fisheries constituency, may be motivated to defer to proposals that may be of short-run benefit to the voters in their area, especially in times immediately preceding elections, rather than focus attention on the broader scope of good fisheries management. Similar behavior is possible, and is indeed happening, at all levels in the institutional structure. Improvements in the dissemination of economic information will likely have little effect on this behavior.

Therefore, because of the lack of economic knowledge itself and a lack of concern for its implementation in some quarters, if the system is to bridge the gap, then the institutional structure will have to be modified to mandate that appropriate attention be given to the economic realities of management. To be truthful, however, such a change will require little, if any, change in the MFCMA and other supporting law. A careful reading of the National Standards and Executive Order 12291 will show that much more emphasis on economics is required than is currently being achieved. The real issue is that no place in the system is pushing for a rigorous interpretation of these points of law or for their strict implementation. In essence, the gap between economic theory and practical fisheries management is blocked by the

nature of the system itself, and by the type of behavior it motivates on the part of many of the individuals in it. As such, the gap is unlikely to be bridged in the near future.

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Literature Cited

Anderson, L. G. 1982a. Living marine resources: Discussion. *In* G. M. Brown, Jr., and J. A. Crutchfield (editors), Economics of ocean resources: A research agenda, p. 67-73. Univ. Wash. Press, Seattle.

_____. 1982b. Marine fisheries. *In* P. R. Portney (editor), Current issues in U.S. natural resources policy, p. 149-178. John Hopkins Univ. Press, Baltimore.

_____. 1984. Uncertainty in the fisheries management process. Mar. Resour. Econ. 1(1):77-87.

_____. 1986. The Economics of Fisheries Management. Johns Hopkins Univ. Press, Baltimore. Rev. ed.

_____. In press. Expansion of the fisheries management paradigm to include institutional structure and function. Trans. Am. Fish. Soc.

_____ and D. R. Lee. 1986. Optimal Governing instrument, operation level, and enforcement in natural resource regulation: The case of the fishery. Am. J. Agric. Econ. 68(3):678-690.

Clark, C. W. 1976. Mathematical bioeconomics: The optimal management of renewable resources. John Wiley & Sons, N.Y.

Fisher, A. C. 1981. Resource and environmental economics. Cambridge Univ. Press.

Frady, T. (editor). 1985. Proceedings of the Conference on Fisheries Management: Issues and Options. Alaska Sea Grant Rep. 85-2.

NOAA. 1986. NOAA fishery management study. Nat. Mar. Fish. Serv., Wash., D.C.

Pontecorvo, G. 1977. Fishery management and the general welfare: Implications of the new structure. Graduate School Bus., Res. Pap. 157, Univ. R. I.

Smith, A. 1776. The wealth of nations. Cannan Ed.

Weingast, B. R., and M. J. Moran. 1983. Bureaucratic discretion or Congressional control? Regulatory policymaking by the Federal Trade Commission. J. Polit. Econ. 91(October):765-99.

Wolf, C., Jr. 1979. A theory of nonmarket failure: Framework for implementation analysis. J. Law Econ. 12(1):107-39.

Bridging the Gap Between Economic Theory and Fisheries Management: Can the MFCMA Produce Economically Rational Management? Discussion

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Discussing the relationship between economic theory and fisheries management is a difficult task to ask of anyone. It is nearly impossible to do when the discussion is restricted to practical aspects. Given the complexity of such a discussion, Lee G. Anderson has provided an excellent discussion on the problems of managing fisheries with the MFCMA, particularly those relating to economics.

More important, I believe, is that Anderson has clearly identified and stated the problems which have limited the management of fisheries in accordance with economic goals and objectives. This has obviously been a source of considerable frustration among economists involved in fisheries management.

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Anderson poses one fundamental question about economics and management. The question is "Is it likely that sound and economically rational management will be produced?" in accordance with economic criteria. The criteria are concerned with proper use of fish and other resources over time with appropriate attention given to all related costs including harvest, programmatic, management, implementation, and enforcement costs. The answer offered by Anderson, and which I concur, is "Not very."

Two reasons why sound management will not be produced are given by Anderson. First, the institutional setting and industry structure hinders management. Second, the politically astute and powerful minorities force attention on self-serving interests or away from economic goals and objectives. These are the same problems identified in the literature on regulating industry (e.g., Buchanan and Tollison, 1984; Crain, 1979; Eckert, 1973; Sen, 1970; Hilton, 1972; McCormick and Tollison, 1981). Other reasons given in the literature for the failure of rational management include issue linkages or making trade-offs explicit among issues, conflicts of interest, and payment of managers and regulators. All of these would appear to be valid causes for the failure to achieve sound economic management of fisheries.

Anderson provides a comprehensive discussion of the institutional setting and structure by which fisheries are managed and regulated under the MFCMA. His paper, in fact, might be more appropriately titled "Collective choice, conflicting criteria, and agency theory in managing fisheries." He notes the existence of multiple objectives, which are often quite diverse; the fact that there are many agents and individuals which affect or are affected by fisheries management; and that, in practice, management is often something upon which all concerned can agree.

One aspect of the institutional setting which is properly accorded rigorous treatment in the paper is the relationship between the Fishery Management Councils and the National Marine Fisheries Service (NMFS). It is proposed that the relationship is one of animosity in which

the Council members and staff believe that NMFS is attempting to make the work of Councils more difficult and to take control of fisheries management. This argument has been heard many times and there is possibly some element of truth to it. On the other hand, NMFS's staff have often complained that the Councils are attempting to exclude them from the management process or are not adhering to the guidelines which must be followed. There also is likely to be some truth to this. However, as correctly indicated by Anderson, these attitudes are not conducive to good management.

There is, though, another problem between the NMFS and the Councils which needs to be resolved. That is the problem of data sharing. Currently, NMFS collects and distributes most of the data necessary for formulating management plans and policies. However, the distribution of the data is often subject to restrictions. These restrictions may result in inadequate data for formulating and analyzing management plans and regulations. Thus, it is uncertain whether or not the council staff are provided the best data available and that management is based on the best available scientific information. The only immediate solution to this problem is for the councils to request particular analyses from NMFS.

Subsequently proposed in the paper is a political "bioregunomic" approach, the purpose of which is to provide an expanded analysis of the entire management process. This includes understanding legislative behavior regarding policy and budgets, enforcement activities, firm behavior, and the stock dynamics. The approach captures the entire institutional structure and allows for the consideration of other activities such as lobbying fishery agencies or the formation of "special interest" groups.

The major importance of the proposed approach is that it indicates that rational economic management requires an understanding of activities by individuals and agencies other than NMFS, the Councils, and the fishing industry, and that fisheries utilization involves other types of management costs. In effect, the political bioregunomic approach focuses attention on a regulated equilibrium and an optimum utilization which considers all economic aspects of firm production, lobbying, avoiding regulation, and instituting and monitoring management policy.

Most economists and managers would concur with the need to consider all the possible interactions suggested by Anderson. However, we must consider the issues of whether or not it is possible to consider all the interactions, and what are the ramifications of not doing so. Previous experience would suggest it is neither possible nor feasible to adequately consider all the interactions of so complex a system. We do not, as yet, appear to be able to deal with even the basic economic and biological issues. Nevertheless, Anderson's argument for considering a broader management framework is correct.

A second question posited by Anderson is "How can the institutional and industry structures be altered such that the regulated equilibrium coincides with the expanded notion of optimal utilization?" Alternatively, "What types of regulation are optimal when the costs related to activities other than fishing are considered?"

A concise answer to this very difficult question is not provided in the paper. There is not, in fact, likely to be an easy answer. As I interpret Anderson, the process of formulating, implementing, monitoring, and enforcing management and regulations is too complex to offer an answer to the problem.

Anderson does, however, imply some possible solutions:

1) Other interests should be represented on the councils (e.g., consumer advocates and planners).

2) Encourage broader response to proposed management plans and regulations.

3) Promote greater cooperation between the states and Councils.

4) Induce the U.S. Coast Guard to act in a coordinated way with NMFS.

5) Specify objectives that have operational significance.

6) Identify a set of alternative plans which specify optimum yield and how the harvest will be limited to that level.

7) Impose a single-source accountability for success of a plan and grant it sufficient latitude and resources to do the job.

There are, though, some possible problems with the implied solutions. First, prior attempts to broaden interests and responses have not been successful; there was often a lack of knowledge or understanding about fisheries and management. Second, some states have legal barriers which prevent cooperation. Third, the Coast Guard has experienced budget reductions, and thus, curtailed its fishery-related activities. They are not likely to increase their level of cooperation without increases in their operating budget. Fourth, if operational objectives are well specified such that trade-offs are permitted, other interests will likely dominate the economic criteria and objectives. Last, a single-source accountability does not necessarily guarantee good management. Currently, the Secretary of Commerce has final approval and is responsible for the fishery management plan. Yet, there is not one FMP with well specified economic goals and objectives.

Overall, I find little to criticize or find fault with in the paper by Anderson. Politics and "back-room bargaining" are an integral part of the management process; they do result in exploitation patterns which are not economically optimum. The fact that there is a trade-off between efficiency and equity in formulating management policies is well recognized; the equity aspects should be considered as well as the efficiency aspects (Layard and Walters, 1978). In general, I am in complete agreement with Anderson that given the economic criteria and institutional structure, it is not very likely that sound economically rational management will be produced under MFCMA.

In diffidence to Anderson, however, I do not believe that the fault lies entirely with the MFCMA. My argument is similar to the statement against gun control that "guns don't kill people, people kill people." In managing fisheries, it is man that specifies goals, objectives, and regulations. The paper upon which the Act is printed provides only a set of guidelines. The fact that Councils and NMFS have elected not to promote efficiency or minimize all costs is their decision. The Na-

tional Standards clearly indicate, where practical, that these conditions shall be considered.

Instead, and with some fear, I offer that the reasons for the failure to achieve rational economical management are our predecessors and we economists of today. Alternatively, I propose that some of the failure is due to 1) our wide acceptance of economic theory and applied methods, 2) our limited and often inadequate economic analysis, and 3) the lack of importance placed on economics by NMFS and the councils.

I do not propose to know all there is to know about economic theory and applied methods. However, I do know that almost every paper or text on determining the optimum rate of exploitation commences with a control theoretic model (e.g., Clark, 1976, 1985; Waugh, 1984). Most often, the objective is to maximize total net discounted revenues of the industry subject to a growth-removal equilibrium condition:

$$\text{Max} \int_0^\infty e(-rt)\cdot[P\cdot h(t) - C(X)\cdot h(t)]dt, \qquad (1)$$

subject to $[F(X) - h(t)]$

where P is output price, h is output, C is cost per unit of h, X is stock size, $F(X)$ is a growth function, r is the social discount rate, and t is time.

Although there have been substantial variations of equation (1) which include multiple objectives, uncertainty, price response to quantity changes, and different growth functions, I think we must ask the question "How can management authorities seriously consider economic objectives if equation (1) cannot be solved if expanded to include Anderson's political bioregunomics framework. A simple expansion of equation (1) is all we have to offer?" It is also quite likely that equation (1) in which demand includes substitute species, cost is not separable between stocks and production, and the production technology varies over firms would likely present a difficult problem to solve.

Equation (1) also suggests another possible failure on our part and relates to Anderson's criteria for an intertemporal harvest plan in which the correct amount is harvested each year. First, is there any reason to believe that any of the economic functions will be constant over all time periods; dynamic processes characterize fisheries. Second, equation (1) leads to either a steady state solution or a "bang-bang" control; we must ask whether these solutions are practical, reasonable, and feasible. Intuitively, I doubt it. Third, if the problem was specified as a finite time horizon problem, how would we establish the appropriate time interval? A quick review of five texts (Chow, 1975; Clark, 1976, 1985; Kamien and Schwartz, 1981; Mangel, 1985) fails to provide any guidance about the relationship between specification, solution, and the selection of a time interval in a dynamic problem.

In practice, I know of no fishery in which the mangement rules were established based on a control model. The problem, in fact, is not caused by the control theoretic approach. The problem is, however, related to the control model. The model serves as a reference for the economic theory and principles used to analyze the economics of fisheries, and it provides the basis for establishing economic goals and objectives of management. The consistent publication of control models in the literature only serves to reinforce its use by economists.

A further examination of equation (1) and relating it to economic theory and research needs illustrates the second possible reason why I believe economists are part of the problem. Most often, the specifications of the economic and growth functions in equation (1) or in other economic models used in fisheries are overly simplified. In many instances, the economic specifications bear no resemblance to economic theory.

For example, what type of inverse demand function has nominal price as a linear function of only the quantity demand. As economists, we know that the ex-vessel demand is a derived demand and should satisfy certain properties. Yet, the managment plans and economic analyses of fisheries abound with these ad-hoc price response specifications. Alternatively, how many fisheries are single-product fisheries. Almost all of the economic and biological specifications of the technology used in fisheries assume the technology is nonjoint-in-inputs or sufficient conditions exist for input and output aggregation. I suspect, as does Clark (1985), that a single-product fishery is quite rare. In the event of multiple products, the economic analysis and determination of optimum yields is likely to be very difficult.

In many of the empirical economic studies of fisheries, ad-hoc economic specifications are used. On occasion, from 5 to 20 equations may be specified and estimated as part of a system, but not one of the equations will be consistent with economic theory. How, then, are such results to be interpreted and applied to fisheries management. More important, what is the valuation of economics by managers when presented with such results.

In a "round-about" way, I am suggesting a need for more basic economic research in fisheries. That is, if economics is to serve as a basis for optimal management, we, as economists, must provide good economic analysis of the basic issues. A partial review of the economic programs and research within NMFS further illustrates this need and highlights the lack of importance placed on economics. NMFS is selected because it is the "national" fisheries agency, and thus, should indicate the importance placed and conveyed to others on the economics of fisheries.

The economics program of NMFS consists of economists located in Washington, D.C., and at several centers, regional offices, and laboratories. There does not appear to be a well defined goal and set of research objectives for the program. However, a substantial amount of analysis and research is conducted by these economists. This includes analysis of ex-vessel prices, productivity, imports, and the technology. Unfortunately, this research is most often reactive or necessitated by a problem which must be analyzed over a very short time-period. These conditions likely prevent the implementation of a basic research program and limit economic analysis.

It is more alarming that, given the level of resources allocated to economics, inadequate but still quite large, there

are no routine economic reports and analysis. I consider the "Fisheries of the United States" publication and similar reports to be data summaries and not economic reports. For example, there is no regular publication on productivity, the status and implications of imports, costs and utilization of the factors of production, short-run price projections, or the economic implications of management plans and regulations. There, in fact, is no routine publication that summarizes the number of fishermen, vessels, landings, and revenue by fishery, region, or state. This type of information is routinely produced by other government agencies concerned with the development, management, and regulation of other industries.

This gives the impression that NMFS is not very concerned with economics. If this is the case, the gap between economic theory and fisheries management is not likely to be narrowed.

To narrow the gap, NMFS must assume a leadership role, at least, in the identification of issues in need of basic research, NMFS, along with the states, universities, Councils, industry, and concerned individuals, must provide substantial resource support. This includes funding, data access, and identification of the issues in need of attention. In turn, our job as economists is to conduct competent research on the basic-issues. I believe we will discover that once we provide competent research on the basic issues, economics will become a significant driving force in the management of fisheries under MFCMA.

Literature Cited

Buchanan, J. M., and R. D. Tollison (editors). 1984. The theory of public choice. Univ. Mich. Press, Ann Arbor, 453 p.

Chow, G. C. 1975. Analysis and control of dynamic economic systems. John Wiley & Sons, N.Y., 316 p.

Clark, C. W. 1976. Mathematical bioeconomics. John Wiley & Sons, N.Y., 352 p.

_____. 1985. Bioeconomic modelling and fisheries managment. John Wiley & Sons, N.Y., 291 p.

Crain, W. M. 1979. Cost and output in the legislative firm. J. Legal Stud. 8(3):607-622.

Eckert, R. D. 1973. On the incentives of regulators: The case of taxicabs. Public Choice 14:83-99.

Hilton, G. W. 1972. The basic behavior of regulatory commissions. Am. Econ. Rev. Pap. Proc. May:47-54.

Kamien, M. I., and N. L. Schwartz. 1981. Dynamic optimization: The calculus of variations and optimal control in economics and management. North Holland, N.Y., 331 p.

Layard, P. R. G., and A. A. Walters. 1978. Micro-economic theory. McGraw-Hill Book Co., N.Y., 498 p.

McCormick, R. E., and R. D. Tollison. 1981. Politicians, legislation, and the economy: An inquiry into the interest group theory of government. Martinus Nijhoff, Bost.

Mangel, M. 1985. Decision and control in uncertain resource systems. Acad. Press, Orlando, Fla., 255 p.

Sen, A. K. 1970. Collective choice and social welfare. Holden-Day, San Franc., 225 p.

Waugh, G. 1984. Fisheries management: Theoretical developments and contemporary applications. Westview Press, Boulder, Colo., 385 p.

Allocating Harvests Between Competing Users in Fishery Management Decisions: Appropriate Economic Measures for Valuation

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ABSTRACT—This paper discusses decision making by fishery managers and economists' efforts to model fisheries. Arguments and casual evidence are presented to suggest that distributional issues matter to managers. The paper concludes with a practical measure suggested as a means of achieving efficiency goals while simultaneously resolving conflicts between competing harvesting groups.

Introduction

Given the motivations for this paper, perhaps the subtitle should be, "Inappropriate Economic Measures for Valuation!" Most fishery economists probably have more experience with inappropriate measures than appropriate ones. All of this, of course, begs the question of how we gauge "appropriate." In general we would argue that where allocation is an issue, most economists would suggest that the end result of any allocation scheme satisfy marginality conditions. These conditions require that the net value of the last pound caught by competing user groups be equal (and equal to zero under open access; the marginal user cost under optimal management). These of course are standard conditions from economic models concerned with efficiency.

Much of the debate in the fishery economics literature has been over achieving efficiency goals (see, for example, the collection of papers in Anderson, 1977—with some exceptions, notably Bromley and Bishop and the collection of papers edited by Pearse, 1979). Excess effort, and the models designed to examine effects of limited entry, may be the single most important problem that fishery economists could have examined, and continue to examine (for a review of the development of economic models for management decisions, see Kellogg, 1985).

These models, as pointed out by Bromley and Bishop (1977), ignore distributional issues for the most part. In this paper, we will discuss some allocational problems faced by managers, and argue that these are, in fact, distributional issues and are likely to be more important (or at least as important) to managers as efficiency issues. We will first address economists' efforts to model fisheries and suggest some generalizations. Finally, we discuss some potentially practical alternatives for managers to consider in decisions and/or in the design of management systems—alternatives that we as fishery economists might address.

The motivations for this paper are several. One of the most important is observation of the difficulty encountered by managers in attempting to allocate allowable harvests between competing harvesting groups. Most of us are familiar with examples, and we have observed these problems in the Gulf and south Atlantic with recreational and commercial competition for red drum, mackerel, and snapper-grouper stocks. In the latter fishery, there are also conflicts among commerical groups.

Overshadowing our thinking about allocation problems are the following:

1) Economists have had an effect on fishery management, and may have even greater effects through more careful interpretation of models, their implications, and their applications to specific problems (i.e., empirical work). However, in the case of recreational-commercial competition for the same species, much theoretical work remains to be done as a foundation for empirical work and policy debates[1].

2) Distributional issues in fishery management decisions matter a great deal. While our experience under extended jurisdiction has a brief history, we do have longer experience and greater observation of management in state waters. There are some lessons from that experience which we will touch on below.

3) Many groups exert pressure on managers for larger shares of allowable catch. Some of the pressure-groups use estimates of value that are inappropriate to the decision at hand.

Why Fishery Managers Aren't Listening (Any More Than They Are) to Efficiency Arguments

Dynamic models usually start with an objective function of maximizing the present value of net benefits of harvest from a given stock, subject to net (of harvest) growth in stock, a harvesting capacity constraint, and an initial population size. This, of course, describes the Clark and Munro (1975) linear model. It generally is used to solve for the optimal path of effort. Colleagues at North Carolina State University have applied a modified

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[1]Development of such models has begun. See McConnell and Sutinen (1979), and Bishop and Samples (1980).

version of such a model to solve for the optimal season opening for the North Carolina bay scallop fishery—a single year-class fishery[2].

Such models and applications are, of course, concerned with efficiency. Our experience tells us that distribution matters, and perhaps we, as economists, ought to think about incorporating distributional issues into our models[3]. How do we accomplish this without violating rules of welfare economics? While we do not presume to have a definitive answer to this question, there are some avenues that are suggested from observing management at the state level which may be worth pursuing.

An economist's objective function in a model is generally oriented toward societal welfare, and its empirical counterpart is usually something like maximization of net economic returns. First order conditions thus generated are efficiency-grounded. We do not question the usefulness of such work (we have used such models ourselves). However, if we want to incorporate distribution issues and develop models that help explain observed behavior, existing models may be overly simplified.

Consider for a moment the objective function of fishery management agencies. Is it to maximize the economic returns to resources engaged in harvesting? We would respond affirmatively, but that managers' objective functions include more arguments[4]. In working with management agencies, it is clear that managers are concerned with income distributional effects of fisheries regulations. One way this is frequently voiced is (in our words) to minimize the heat on the agency from irate fishermen. And irate fishermen are defined as losers, or those who perceive losses, from a particular policy[5].

In addition to the problems we have in specifying models that might allow us to evalute tradeoffs between efficiency and distribution, we also have problems in estimating models. In most fisheries in the Gulf and south Atlantic region, there are no catch-effort data, and at best, imprecise estimates of stock. As Crutchfield (1972) has observed, we are likely to find "barn door" variances. Crutchfield (1977) also cautioned that we should try to formulate models that reduce, rather than increase, our demands for data. While such a goal may be inconsistent with adding distributional arguments to our models, let us pursue for a moment an example of Crutchfield's concern.

If we think for a moment about the Gulf mackerel fishery, we have a fishery considered to be in potential biological trouble. Both commercial and recreational fishermen harvest the resource (about 2/3 and 1/3 shares, respectively), and stocks apparently fluctuate significantly from year to year. Now, consider the problems that would be encountered with estimating a complete model of this fishery. Then, consider the problems of updating estimates of marginal values for fluctuating stocks, and the required timeliness of getting those estimates to the Gulf and South Atlantic Fishery Management Councils for appropriate decisions. Perhaps we ought to think of such estimates as yielding helpful information on desired direction of change of total catch, and, if we are lucky, for direction of change in catch for the two harvesting sectors. (Actually, all of this is further complicated by large catches by Mexican fishermen as well.)

Council's solution has been a bag limit on recreational fishermen, and a catch quota for commercial fishermen (once the commercial quota is reached, that fishery shuts down). This may well not be the best solution, but both harvesting groups seem willing to live with it. It may not be the worst possible solution either.

Given poorly specified models for allocation problems and the data problems we face, it should not surprise us that managers put less weight on efficiency objectives than economists do. (That is a polite way of saying that they may not be listening as much as we would like.) But before we throw our hands up in dismay, perhaps we should examine some reasons for this state of affairs.

Decision Making by Fishery Managers

In no way do we intend this discussion to be critical of fishery manager efforts. Management agencies are charged with overseeing fisheries in society's interest, but actions are definitely affected by constraints faced, especially political constraints[6]. Furthermore, the agency's objective functions themselves may be modified by fishermen who are the immediate group the agency is charged with serving.[7].

An example might help illustrate this point. For years the North Carolina bay scallop fishery has opened in early December, in spite of rapid growth of a scallop's meat through the winter months and price increases as the New England catch decreases. Why the early opening? A few very vocal fishermen have dominated public hearings—in favor of the early opening to earn "Christmas money." Several hypotheses have been offered to explain this method of financing Christman expenditures. The two most likely explanations are:

1) Lack of access to credit markets, and

2) Aversion by those vocal fishermen to being on the water in the usually worse weather of January and February.

If taken literally, the second argument is like the well accepted theory of compensating differentials in the determination of wages. Such differentials are legitimate arguments in social welfare. Note, however, that this argument also contains the issue of income distribution.

[2]For a description of the model and results, see Kellogg, Easley, and Johnson (1985).

[3]For example, Crutchfield (1972) and Bishop, Bromley, and Langdon (1981) discuss incorporating more general objectives than simply maximum economic returns.

[4]We economists may have too long ignored the role of a management (and/or regulatory) agency.

[5]Note that there is no such thing as tenure for most directors of management agencies.

[6]An interesting variation of this argument is made by Baden and Stroup (1978) who contend that some government agencies have reduced environmental quality in pursuing the agency objective(s). Such results occur because the environment is a public good, and authority and responsibility for actions are separated.

[7]There are some interesting questions surrounding the accuracy with which managers translate the interests of fishermen into policy. Surely this translation is not without variance, and that variance may be large.

If in fact these fishermen have a distaste for fishing during colder months, then by shifting the season forward, they may be assured of a larger share of the catch. In any event, these hypotheses may be put to the test when the North Carolina Marine Fisheries Commission goes to public hearings in the fall with a recommendation of delaying the season opening until January[8].

What this example suggests is, in effect, that managers act as if their objective function included something like: Minimization of changes in the income distribution of harvesters (or groups of harvesters). Another even clearer example of this is in the Pamlico Sound (North Carolina) shrimp fishery. Small boats trawl the shallow bays and estuaries; large boats trawl the main body of the sound. Small-boat fishermen want the shrimp season opened earlier while more shrimp—though smaller in average size and price—are abundant in the bays. Large-boat ("hog boats" to the small boat fishermen) pressure managers to open the season later when the shrimp have grown and are migrating across the Sound toward the ocean. The season usually opens while there are still shrimp in bays. These are smaller shrimp, but the purpose is to make available part of the stock to small boats. Public hearings on when to open the season are animated events, but this is clearly a distribution issue between two groups of commercial fishermen. Shrimp and bay scallops are single year-class fisheries, and biologists believe next year's stocks are unrelated to this year's harvests. Hence, population constraints are less binding and this may mean that distributional issues assume added weight.

Similar distributional issues could be cited (see, for example, cases reviewed by Bromley and Bishop, 1977), as well as issues involving gear conflict. But our point is that some argument appears to exist in the decision function of management agencies that incorporates distributional effects. There may be better specifications, but for lack of a better definition, we refer to it as minimization of political disfavor[9]. That there are trade-offs between efficiency and political objectives of management surprises no one. But what is surprising is that we have not attempted to explicitly incorporate political objectives and constraints into our models.

In a sense, a start in this direction has been made by McConnell and Sutinen (1979) in a model that jointly maximizes consumer and producer surplus with both commercial and recreational harvesting. From this model, they find that allocation of harvests depends critically upon the own-price elasticity of effort in each of the fisheries (where price is the derived demand price for each type of effort). The optimal mix of catch would favor the harvesters with the relatively smaller own-price elasticity (less elastic). They argue (p. 134) that this result ". . . suggests that prescribed allocations between commercial and recreational fishers based on historical catch shares can result in allocations significantly different from the efficient allocation."

Bishop and Samples (1980) also model a fishery with recreational and commercial conflicts, and include harvesting capacity constraints for both harvesting sectors. In their linear model, movement along the optimal time path requires either recreational or commercial fishing to go to zero if net benefits of the last pound caught is not equal in the two harvesting sectors. This conclusion may be modified by capacity constraints, i.e., if insufficient capacity exists in the favored sector to harvest the optimal quantity, then the other sector becomes the "residual claimant." They also raise an important question about the effect of stock on net benefits per pound caught in the two sectors. They speculate that at some levels of stock, net recreational benefits per pound exceed net commercial benefits per pound, and for other stock levels, the reverse could hold. In their nonlinear model, harvestable surplus is divided between sectors such that marginal net benefits are equal. They also note (p. 228) that ". . . once demands for recreationally and commercially caught fish become downward sloping in g and h [harvesting rates], respectively, the two groups will share in the steady-state harvest unless $\hat{R}$ and $\hat{C}$ [Total net benefits in the two sectors, respectively] are such that a corner solution occurs."

We would like to summarize their important conclusions (p. 231-2):

1) Models (linear and nonlinear) show multiple use of fishery resources may be optimal.

2) The relative economic merits of sport and commercial fishing must always be compared at optimal population levels [otherwise we may get greatly biased estimates of relative net benefits].

3) Entry of recreational fishermen into a previously commercially exploited fishery (under the nonlinear model) increases the size of the steady-state biomass. Similarly, "if commercial fishermen begin exploiting a population which serves as prey for a recreational species, optimal management would require a reduction in the population of the predator species."

We think these papers are important contributions to the recreational-commercial allocation debate. However, we add one last anecdote: Regarding the last conclusion, the North Carolina Marine Fisheries Commission recently retricted the commercial menhaden fishery to fishing some distance off shore. Menhaden is a prey species for many recreationally and commercially harvested species; however, recreational fishermen were advocating the restriction, and greatly outnumbered commercial menhaden fishermen.

This apparent paradox suggests again that we look at political tradeoffs to efficiency objectives. Such models would allow more complete comparisons of management as sometimes observed, and management for efficiency goals. One wonders, for example, how the steady-state stock generated from a more politically-oriented model would compare with that generated from efficiency-based models. In addition to the implica-

[8]The Commission did delay opening the season in 1986 based on the work reported in Kellogg et al. (1985). Let us hope we were correct.

[9]A student of the economics of government agencies might argue that economists should perhaps specify the objective function with some other politically-oriented argument, and include in the model a distributional constraint. In any event, interesting hypotheses may emerge from a marriage of public choice and fishery models.

tions quoted above, there is some casual evidence to suggest the steady-state stock resulting from such a generalized model would be smaller.

Some Practical Measures for Promoting Efficiency and Resolving Conflicts

We make no pretense about having problems with this topic: We have no magic wand. However, allocation decisions are being made, and many of us are uncomfortable with attempting to offer advice. And like many economists, we have done our share of lamenting the lack of data with which we are confronted. Allocation decisions will be made. The question is, can economists assist? We think yes. We propose the following ways:

1) First, with more complete development of theoretical models to assist in the debate over allocation issues and to help guide public policy. And more general models may be necessary.

2) Application of models to specific problems to quantify costs and benefits of proposed actions.

3) Do a better job of conveying to managers and the fishing public the implications of our analyses.

The demand for theoretical work is obvious and overdue, especially in the increasingly important competition between recreational and commercial fishermen. The only thing we would add is that, following the discussion in the previous section, it may be productive to include managers' objectives (reflecting competing fishermen) into our models' objective functions and/or constraints.

Regarding application of models to specific allocational issues, several questions arise. We quote from the conclusions of Bishop and Samples (1980:232):

> . . . recreationally caught fish have usually been valued at either their recreational benefits per pound or expenditures per pound. On the commercial side, the value of the catch has usually been set at the dockside price. A number of problems with this approach are immediately apparent. First, costs are not adequately taken into account. Commercial fishing costs are ignored entirely. While recreation benefits measured, say, by the travel cost method are net of costs borne by the recreationists directly, other costs such as those for stocking and management may go unrecognized under this approach. Second, even where the recreational benefits are adequately measured—and obviously angler expenditures are inappropriate—benefits per pound constitute a measure of average rather than marginal benefits. It is marginal benefits that are important for allocation decisions and, except for the special case portrayed in the linear model, average benefits will exaggerate the contributions of recreational fishing at the margin. Third, such comparisons may fail to capture the true economic relationships between sport and commercial fishing by considering relative values only at the current level of the fish population. We have shown here that the relative economic contributions of sport and commercial fishing should be considered across a broad range of biomass levels. Finally, when more than one species of fish is involved, as in our predator-prey model, the interaction effects between the two species become an additional consideration that must be weighed in defining efficiency conditions.
>
> Clearly economists have much more work to do before they can adequately assist public decision-makers confronting conflicts between sport and commercial fishermen. A top priority has to be adequate assessment of the derived demand for recreationally caught fish. While we have blithely talked of the demand for recreationally caught fish . . ., the fact is that present demand work focuses almost entirely on the demand for entire recreational products measured in days of recreation. Fish are only one input into recreational fishing. To attribute the entire benefits of fishing to the fishery resource is like attributing the entire benefits of farming to a single input such as fertilizer . . . .

There is obviously much work to be done. Marginal valuation has to be an improvement over some techniques now used in arguments, such as: Total recreational expenditures last year were estimated at $X, which greatly exceeds the value of commercial landings in the same year of $Y; therefore, we (recreational) fishermen deserve exclusive harvesting rights. One occasionally hears similar arguments from the commercial side, sometimes couched in terms of employment.

Much preferred to such casual valuation techniques would be estimation of a model such as Bishop and Samples (1980). Yet they acknowledge problems in generalizing from such estimates based on participation in fisheries with biomass well away from the optimal size. This may describe many of our fisheries which are exploited by both recreational and commercial fishermen. And while on the one hand we believe such work to be helpful, we are also concerned about the data requirements and timeliness of such work.

There is yet another possible approach to the allocation problem (whether between groups of recreational fishermen, recreational-commercial, or between commercial fishermen). Economists have long discussed alternatives for limiting entry, including various property rights schemes such as restricted licensing and allocated quota. We are not familiar with applications of these schemes to recreational-commercial conflicts. Rights to access or to a given quantity of fish may be more acceptable to fishermen as a means of allocating the resource between competing users than as a means for achieving efficiency goals. Marketable fishing rights may automatically solve the distributional problem. One would expect the offer price by, say, a commercial fisherman for X pounds per year (or access to a fishery) to roughly reflect his discounted net earnings. He presumably sells at a price with which he is satisfied.

Several objectives could be raised to such a use of property rights. One is that the common property problem prevails, and it would be in no single recreational fisherman's interest to purchase rights (especially if there is a lumpiness problem). To that we respond that we would not be surprised to see fishing clubs, tournament sponsors, etc., purchase fishing rights or quota (as clubs have leased stream bottom for fresh-water trout fishing). Note that this example implicitly assumes growth in recreational demand relative to commercial demand for harvests.

Institutional arrangements that would allow such a market to function do not now exist. However, we note that these

arrangements have been developed for property rights to access or harvest of other resources.

Another objection frequently raised with proposed allocated quota schemes is enforceability. We usually assume away enforcement costs, or assume that they are the same for alternative actions (which makes them irrelevant). Do enforcement costs vary by policy? We suspect so, but have no real evidence. In our region of the country, given extremely low probabilities of detection, and relatively low fines if caught and convicted of a violation, then the expected value of the cost of a violation is quite low (approaching zero?). Certainly one alternative would be to increase the size of the fine if probability of detection of violation remains low.

There would, of course, be many practical problems to solve before implementing such schemes. Does the management agency simply issue access rights, first-come first-served? Or does it auction them? Does it assign access rights or quota to everyone currently in the fishery, then cancel those rights as participants leave the fishery in order to achieve efficiency objectives? Does it allow markets for those rights to function, solving the allocation problem? What is the optimal tax on transfers? And how do we minimize rent-seeking activity if a fund is created?

These are illustrative of the types of questions raised regarding various property rights schemes for limiting entry, and apply as well to use of such rights for allocation purposes. However, they may offer a viable alternative for solving allocational problems, particularly between recreational and commercial conflicts—conflicts where in many cases timely empirical results are not likely to be available.

Summary and Implications for Research

We have discussed two ideas that may merit some attention by economists. The first is developing models that explicitly include management agency objectives against which efficiency goals are traded off. We have argued that there is much casual evidence that income distribution matters in management decisions. Some of this evidence and observation suggests that some measure of distributional effects of a policy may enter managers' objective functions directly. Yet it may make more sense to specify a politically-oriented argument for the objective function, with changes in the distribution of income acting as a constraint. Results such as optimal harvest and biomass from such a model compared with results from models concerned only with efficiency would provide some information on tradeoffs between those goals. Such models and research may also suggest hypotheses about why we may come closer to achieving efficiency goals in some fisheries than in others.

The second idea discussed is the potential use of some property rights scheme to allocate harvest between competing fishermen. Such a scheme may have merit in a fishery exploited by both commercial and recreational fishermen. Note that transferable fishing rights could be used to solve the allocation problem, and could initiate movement toward efficiency goals. Little information about the relative value of competing uses would be required by managers since a market for rights solves the efficiency problem. A market also has the inherent flexibility to adjust to changing circumstances. We conclude that a property rights scheme to promote markets in fishing rights (or stocks) seems ideal.

We believe both of these ideas deserve further study. We also endorse Bishop and Samples' (1980) suggestions that greater thought be given to modeling the derived demand for fish as an input into recreational fishing. Recreational-commercial conflicts are likely to intensify, at least in the Gulf and south Atlantic. Development and application of such models could be extremely useful to managers in the years ahead.

Acknowledgments

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Literature Cited

Anderson, L. G. (editor). 1977. Economic impacts of extended jurisdiction. Ann Arbor Sci., Ann Arbor, Mich.

———. 1981. Economic analysis for fisheries management plans. Ann Arbor Sci., Ann Arbor, Mich.

Baden, J. A., and R. L. Stroup. 1978. The envionmental costs of government action. Policy Rev. 4:23-36.

Bishop, R. C., and K. C. Samples. 1980. Sport and commercial fishing conflicts: A theoretical analysis. J. Environ. Econ. Manage. 7:220-233.

———, D. W. Bromley, and S. Langdon. 1981. Implementing multiobjective management of commercial fisheries: A strategy for policy-relevant research. *In* L. G. Anderson (editor) Economic impacts of extended jurisdiction, p. 197-218. Ann Arbor Sci., Ann Arbor, Mich.

Bromley, D. W., and R. C. Bishop. 1977. From economic theory to fisheries policy: Conceptual problems and management prescriptions. *In* L. G. Anderson (editor), Economic impacts of extended jurisdiction, p. 281-301. Ann Arbor Sci., Ann Arbor, Mich.

Clark, C. W., and G. R. Munro. 1975. The economics of fishing and modern capital theory. J. Environ. Econ. Manage. 2:92-106.

Crutchfield, J. A. 1972. Economic and political objectives in fishery management. *In* B. J. Rothschild (editor) World fisheries policy: Multidisciplinary views, p. 74-89. Univ. Wash. Press, Seattle.

———. 1977. Evaluation of the economist. *In* L. G. Anderson (editor) Economic impacts of extended jurisdiction, p. 381-386. Ann Arbor Sci., Ann Arbor, Mich.

Kellogg, R. C. 1985. A bioeconomic model for determining the optimal timing of harvest with application to two North Carolina fisheries. Ph.D. dissert., Dep. Econ. Bus., N.C. State Univ., Raleigh.

Kellogg, R. L., J. E. Easley, Jr., and T. Johnson. 1985. A bioeconomic model for determining the optimal timing of harvest for the North Carolina bay scallop fishery. Univ. N.C., UNC Sea Grant Publ. UNC-SG-85-25.

McConnell, K. E., J. G. Sutinen. 1979. Bioeconomic Models of marine recreational fishing. J. Environ. Econ. Manage. 6:127-139.

Pearse, P. H. (editor). 1979. Proceedings of the symposium on policies for economic rationalization of commercial fisheries. J. Fish. Res. Board Can. 36(7).

Allocating Harvests Between Competing Users in Fishery Management Decisions: Appropriate Economic Measures for Valuation. Discussion

JAMES L. ANDERSON

The evaluation of appropriate economic measures for analyzing the allocation of harvests between user groups is difficult. There appears to be no universal principle for guiding management's allocation decisions and most of the deisions depend on political and social realities of individual situtations. As such, discussions on this topic usually consist of anecdotal observations complemented with some economic intuition which conclude that more careful economic analysis can help in assisting managers in their allocation decisions. The paper by Easley and Prochaska uses this approach to make some solid observations which highlight the issues and the limitations of current economic research. Most of my comments will focus on underscoring the issues and scope of the problems and will reemphasize the limitations of the current economic research which I feel Easley and Prochaska tended to understate.

Although Easley and Prochaska discuss allocation problems other than the commercial/recreation problem, the authors could have expanded upon the full range and magnitude of allocation problems. In the case of Pacific salmon, for example, the user conflicts include allocation questions involving commercial fishing, recreational fishing, aquaculture interests, Native American fisheries, Canadian users, allocation between gear types within commercial fisheries, and regional distribution of salmon resources. Although allocation and optimal stock levels cannot truly be separated, the dominant issue in the Pacific salmon fishery is probably the allocation issue, but not just recreation/commercial fishery distribution.

In a more general sense, fisheries allocation problems include gear conflicts (between and within fisheries), part-time versus full-time operations, inshore versus offshore fishermen, foreign versus domestic allocations, and distribution of domestic catch regionally and over time. In addition, further along the market chain, allocation questions involving fishery resources include import/export allocation and how the resource is to be processed (domestically on shore, by domestic vessels at sea, by foreign vessels at sea, or in foreign plants). This last resource allocation question has been the pivotal element in recent disputes over joint ventures.

I feel that it is important to underscore the range of user group conflicts in order to clearly illustrate the magnitude of the allocation problem. When those familiar with the fisheries economics literature consider these allocation issues, they will notice the remarkable lack of research on most of these problems.

As Easley and Prochaska indicate, more modeling which attempts to capture the manager's objective function is needed. To say the least, fisheries economists have barely scratched the surface. Fisheries economists need to attempt to understand not only the objective functions of managers, but also the strategic behavior of the user groups when faced with use conflict in a regulated environment. Until we have a better understanding of the latter, allocation rules and regulation will fall short. In the area of user behavior, fisheries economists could probably gain much by considering the work in the fields of industrial organization and game theory. In terms of modeling manager's politically oriented objective functions, as Easley and Prochaska suggest, I would expect fisheries economists will have only limited success.

An alternative approach to directly modeling the manager's objective might be the development of goal (goals may be employment, income distribution goals, efficiency, fish stock and harvest goals) frontiers as a function of policy mixes and budget constraints. Once the frontier is developed, the manager could then choose among the feasible frontier options. This approach avoids imposing the view that efficiency is all that matters. These goal frontiers could be constructed by various mathematical programming techniques.

Other aspects of the Easley and Prochaska paper that need additional consideration are their comments on property rights schemes. They suggest that individual transferable quotas may solve the allocation problem while moving toward efficiency. First the question of workability of such schemes is in doubt unless, as in the case of New Zealand fisheries, the resource is relatively well defined and separated from other species, the fishermen are basically in agreement with the concept, and there exists a monitoring system which is much more invasive than any that presently exist in the U.S. food-related industries. Workability aside, property rights schemes really do not necessarily help in in solving allocational and distributional questions. Initial conditions of wealth and entrenchment of certain users will influence allocation of rights (leading to possible inequitable initial distribution). There is no reason to expect the market for rights to be anywhere near perfect, especially if nonfishermen are excluded from the market. This will result in inefficient allocations. The inability to define

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precisely the resource also leads to inefficient allocation. The rents captured from the property rights scheme and rent redistribution is another area where inefficient and inequitable allocations may result. Easley and Prochaska mention some of these as "practical" problems; however, I feel they are critical distribution/allocation problems.

In conclusion, the Easley and Prochaska paper points out many of the issues relevant to analysis of allocating of fishery resources between user groups. However, after reading this paper one is disheartened by the lack of research by fisheries economists which could actually be useful to fishery managers in their allocation decisions.

Enforcement of the MFCMA: An Economist's Perspective

JON G. SUTINEN

Introduction

The Federal government spent more than $220 million in FY 1985 to carry out the Magnuson Fishery Conservation and Management Act (MFCMA), and nearly 60 percent of these expenditures were for enforcement of the regulations promulgated under the Act. In late 1985 Federal fisheries enforcement effort was reduced substantially when the U.S. Coast Guard's budget was cut. Sea patrols by the Coast Guard in the Northeast Region, for example, were cut in half as a result.

What are the welfare consequences of this reduction? Can it be justified on economic grounds? Are further reductions in the best interest of the fishing industry, consumers of fish, and taxpayers? Or, is more enforcement justified despite its high cost? A naive observer might expect to find answers to such questions in the Regulatory Impact Analyses (RIA's) required by Executive Order 12291 for regulations under the MFCMA. The RIA's prepared to date, however, do not provide an adequate accounting of the welfare impacts of enforcement and provide little or no information for determining the appropriate level of enforcement. I can only speculate on the reasons for this information gap. The lack of appropriate data likely is a principal reason. But another important reason appears to be the lack of an applied benefit-cost framework tailored to evaluation of the fisheries law enforcement program.

This paper describes a framework for evaluating fisheries law enforcement and uses available data to illustrate its application to evaluation of MFCMA enforcement. The main body of the paper presents the following sections: 1) An overview of the regulations and enforcement programs under the Act, 2) a basic paradigm for explaining the incidence of violations in a fishery is developed, 3) a model for measuring the effects of regulatory and enforcement policies on compliance and benefits is outlined, 4) the nature and magnitude of enforcement costs are discussed, and 5) some conclusions are drawn in the final section.

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Regulations and Enforcement Under the MFCMA

Under the MFCMA, regulations specified in management plans may include:

1) Limitations on the catch of fish based on area, species, size, number, weight, sex, incidental catch, total biomass, or other factors;

2) Designated zones where and when fishing is limited or permitted by specified types of vessels or gear;

3) Prohibitions, or other controls, on specified types and quantities of fishing gear, fishing vessels, or equipment for fishing vessels; and

4) A system of limiting access to a fishery.

Catch limitations are the most prevalent of the above regulations, followed by time-area closures and gear restrictions.

Catch limitations most commonly take the form of an aggregate annual quota for specified species and areas. When the recorded catch for the year equals or exceeds the quota, the fishery is closed. Other common catch limitations include restrictions on incidental catches (i.e., of nontargeted species) on both a trip and aggregate basis. Restrictions on the size of fish landed are used in a few fisheries.

Time-area closures (i.e., designated zones where and when fishing is prohibited) have been used in most fisheries subject to management plans. It is common to combine this form of regulation with others—e.g., catch limitations and gear restrictions.

Gear restrictions appear to be slightly less common than time-area closures. The regulation usually specifies the type or size of gear allowed in the fishery. In trawl fisheries, for example, the mesh size of the codend must not be less than a specified length when measured a certain way; and only barbless hooks may be used to catch Pacific salmon off the west coast.

Restricting access to a fishery is not common, though some forms of the regulation are found in FMP's for Alaska high-seas salmon; Washington, Oregon, and California commercial and recreational salmon; and Atlantic surf clams and ocean quahogs.

Management plans typically employ multiple regulations. The FMP for the relatively simple northern anchovy fishery uses three types of regulations: Aggregate annual catch quotas, time-area closures, and restrictions on the minimum size of the fish landed. FMP's for more complex fisheries, such as groundfish and salmon, use a greater array of regulations.

Enforcement of the law and regulations under the MFCMA is the joint responsibility of the U.S. Coast Guard (Department of Transportation) and the National Marine Fisheries Service (Department of Commerce). Fisheries law enforcement activities of the Coast Guard traditionally have been limited to surveillance and inspections of offshore fishing operations. NMFS personnel frequently

accompany Coast Guard fishery patrols, making the offshore enforcement activity a joint endeavor. Onshore, or dockside, enforcement of the MFCMA has been the traditional responsibility of NMFS in conjunction with state enforcement agencies.

Offshore enforcement is composed of three principal modes: Observers, sea patrols, and air patrols. The observer program operated by NMFS places an individual on board each foreign vessel to monitor its fishing activities. No observers are placed on domestic fishing vessels. While observers have no authority to take enforcement actions, they fulfill an important role in the enforcement process. Besides monitoring and recording the foreign vessel's activities, they can summon enforcement personnel if a violation is suspected. According to Pallozzi and Springer[1], observers are a good mode for monitoring compliance with nearly all management regulations. Under the current program, the cost of observers is borne fully by the governments of the foreign vessels.

Sea patrols by Coast Guard ships and boats is the most comprehensive enforcement mode. Ship and boat patrols can both detect and apprehend violators and can be conducted in all weather where fishing takes place. Large ships can remain on scene in a location far from port for long periods, while smaller boats present a less obvious enforcement presence. Boardings at sea from such patrol ships and boats provides detailed information on catch, gear, processing, and data reporting requirements. Boardings cannot monitor the fishing operations as completely as an on-board observer, who can conduct nearly continuous monitoring, but is still regarded as a very effective technique for monitoring compliance. The principal disadvantage of boardings at sea is their high cost[1].

Air patrols are typically used to search large areas to determine the number, type, and identity of fishing vessels. As provided by the Coast Guard, air patrols range from large, long-distance, fixed wing craft, such as the C130, to helicopters flying short-distance sorties off the decks of cutters. Air patrols can detect limited types of regulatory violations. Violations of time-area closure regulations can be readily detected by air patrol surveillance; however, violations of catch limitations and gear restrictions are usually impossible to detect from the air. Of course, air patrols cannot directly apprehend suspected violators. Dockside personnel or surface vessels must be called in to board the vessel and issue the citation. Air patrols also are often limited by weather conditions. In sum, air patrols are an important complement to other enforcement modes and cannot be expected to achieve enforcement goals alone.

Onshore, or dockside, enforcement modes include monitoring landings, inspecting primary buyers (dealers/processors) and general investigation. Dockside monitoring of a vessel's landings for species, sizes, and quantities is easier and much less costly and, therefore, can be more complete than at sea. Dockside monitoring cannot reliably determine where fish were caught or what gear was actually used. Since most foreign vessels do not normally land their catch in domestic ports, dockside monitoring requires bringing the vessel to port, a time consuming and expensive process. Inspecting primary buyers of fish can be effective for detecting violations of minimum size and prohibited species regulations. Typically there are relatively few primary buyers, making this mode a low-cost means of monitoring landings. Of course, this mode is incapable of detecting violations of gear restrictions, closed areas, and individual trip or vessel quotas. According to the enforcement guidelines (NMFS[2]), investigation includes undercover operations, radio monitoring, data analysis, use of informants, and casual conversation with fishermen and primary buyers. The investigation mode is often used to detect organized and repetitive violations, and can provide information on compliance and effectiveness of an enforcement program.

There are four principal types of enforcement sanctions: Citations, violations, seizures, and permit sanctions. A citation is a written warning involving no penalty, usually issued for a technical infraction or an infraction of minor consequence. A violation is a civil penalty, issued for serious infractions and carries a maximum fine of $25,000 per day of violation. A seizure of a fishing vessel is reserved for gross, flagrant infractions of conservation or criminal laws and carries a maximum penalty of a $100,000 fine and/or 10 years imprisonment plus forfeiture of the vessel, gear, and catch. A permit sanction revokes or suspends an individual's fishing permit. Civil penalty actions resulting from violations are the most common enforcement sanction, followed by citations, seizures, and permit sanctions.

Explaining the Incidence of Violations

A framework for evaluating the costs and benefits of enforcement must be based on a sound paradigm explaining the behavior of individuals subjected to regulatory constraints. The paradigm adopted here is one commonly used in the economics literature on criminal behavior[3]. The paradigm views individuals as rational decision makers who weigh the relative gains and losses of compliance and noncompliance when subjected to regulatory constraint. That is, the decision whether to comply with the regulation is based on which alternative maximizes the individual's welfare.

The decision making environment for individual firms facing MFCMA regulations is portrayed in Figure 1, which is presented in the form of a decision tree where Y represents an affirmative response and N a negative response to the decision question in the associated pentagon. The rounded rectangles contain the economic consequences for the firm of a decision or action taken by the firm or regulatory authorities. The P's in parentheses next to the Y's and N's rep-

[1]Pallozzi, M. M., and S. C. Springer. 1985. Enforcement costs in fisheries management: The alternatives: Paper presented at the Workshop on Fisheries Law Enforcement, Univ. R. I., Oct. 1985.

[2]NMFS. 1982. Guidelines for Regional Fishery Management Councils on enforcement considerations (draft). Unpubl. memo., NMFS, Wash., D.C.

[3]Becker (1968) is widely recognized as the progenitor of this paradigm. An important elaboration of the paradigm was made by Stigler (1970). For a formal adaptation of the paradigm to fisheries law enforcement, see Sutinen and Andersen (1985).

resent the probabilities that the Y or N outcome occurs.

Starting near the top of Figure 1, we see that if a management plan for a fishery (FMP) is implemented, then regulations (R) are issued. If the firm complies with the regulations, its economic consequences are the resulting profits represented by π (comply). If the firm decides not to comply with the regulations and its violation is not detected (with probability (1-P)), its resulting profits are represented by π (violation). If the firm's violation is detected and the firm is prosecuted, it faces a penalty and legal fees denoted by PEN and LF, respectively. Therefore, the firm's resulting profits are of the form π (violation) $- LF - PEN$.

As can be seen from Figure 1, several outcomes are possible for the firm. This environment and the decision making paradigm for compliance are now modestly formalized in order to develop a framework for evaluating fisheries law enforcement.

To begin, I define A as an ordered n-tuple of activities, $(a_1, a_2,\ldots,a_n)$, by the fishing firm which are subject to regulation. These activities may include the date and location of fishing, the type, size, and quantity of gear used, the total quantity landed of specific species, etc. R is defined as an ordered n-tuple of regulations or regulatory constraints, $(r_1, r_2,\ldots r_n)$, imposed on the activities in A. I denote the firm's compliance with a single regulation, say r_u, by $a_u \leq r_u$, and with all regulations by $A \leq R$. That is, $A \leq R$ holds if $a_i \leq r_i$, for all $i = 1,2,\ldots n$. Noncompliance with, or a violation of, any one or all of the regulations is denoted by $A > R$. That is, $A > R$ if $a_i > r_i$, for any $i = 1,2,\ldots n$.

The firm's profits depend on its set of activities A, i.e., $\pi = \pi(A)$. Some or all of the regulatory constraints R are said to be binding on the firm when $\pi(A|A > R) > \pi(A|A \leq R)$. In other words, the regulations are binding when violation can bring the firm greater profits.

With a program to enforce the regulations R, penalties are imposed on those firms convicted of violating the regulations. In practice, the penalties include monetary fines, confiscation of catch, gear, and vessel, suspension and revocation of fishing permits, and imprisonment.

Of course, not all violators are convicted and penalized under the existing imperfect enforcement and adjudication system. If a firm does not comply with the regulations, it may be detected with probability P_1 or not detected with probability $(1 - P_1)$. The several remaining steps in the prosecution process are portrayed, along with the probabilities of alternative outcomes, in Figure 1. The final consequences for the firm's profits are also given in Figure 1. To simplify the notation I define π (comply) $= \pi(A|A \leq R)$ and π (viol) $= \pi(A|A \geq R)$. LF denotes the legal fees and other costs borne by the firm when dealing with enforcement authorities, where $LF_1 < LF_2 < LF_3 < LF_4 < LF_5 < LF_6$ is assumed. The penalities are as follows:

Full penalty (denoted by PEN_F)—the penalty prescribed by the penalty schedule.

Partial penalty (PEN_P)—an amount less than the full penalty.

Court penalty (PEN_c)—the penalty prescribed by the Administrative Law Court following conviction.

The behavioral paradigm assumes the decision maker for the firm decides whether to comply with the regulations by comparing the profit consequences of complying with the profit consequences of violating the regulations. Let's look at this decision in more detail. Assuming the firm is risk neutral, it makes decisions to maximize expected profits. In general, expected profits are given by the equation $E\{\pi(A)\} = \pi(A) - E\{LF(A)\} - E\{PEN(A)\}$, where the expected legal fees $E\{LF(A)\}$, and expected penalty, $E\{PEN(A)\}$, are positive if $A > R$, and zero otherwise[4]. The decision whether to comply is determined by the rule: Violate/comply as $\pi(A|A \leq R) < / > E\{\pi(A|A > R)\}$. Simply stated, if the expected return from violating a regulation is greater than the certain return of complying, then the firm will commit a violation.

The profit functions above depend on several variables (both endogenous and exogenous) which typically vary over time, such as prices, fish stock abundance and location, species composition, and weather. Such changes in conditions can clearly change the incentive to violate regulations. Hence, a given fishing firm may decide to violate a few regulations only a few times during the year, and another firm, facing different conditions, may decide to violate most regulations most of the time during the year. In addition, some firms behave differently because they hold different perceptions of the probabilities of detection and conviction. The framework here assumes decisions are based solely on the outcome for expected current profits, when, in reality, firms likely consider the stream of expected future profits and perhaps noneconomic factors such as social status in the community. Therefore, we cannot expect the simple decision rule—based on comparing profits from complying with profits from violating—to apply strictly in practice. My principal point here is that in any fishery the incidence of violations will vary across the fleet (with some firms committing more violations than others) and over time (as well as across space and other dimensions). Despite these additional considerations, the incidence of violations will be influenced by the probabilities, penalties, and regulations in the same way as predicted by the simple framework developed above. Specifically, higher probabilities and penalties can be expected to increase compliance in a fishery.

The simple theoretical framework developed here is used in the next section to outline an applied model for measuring the effects of regulatory and enforcement policies on compliance in the benefits from a fishery.

[4]For the system portrayed in Figure 1,

$$E(LF(A)) = P_1 \cdot P_2 \cdot \left(\sum_{i=1}^{6} w_i l_i \right),$$

$$E(PEN(A)) = P_1 \cdot P_2 \cdot P_3 \cdot \left(\sum_{j=1}^{3} p_j \cdot PEN_j \right),$$

where w_i is the conditional probability (given a NOVA has been issued) the ith route to final resolution occurs, l_i is the added legal fees of the last step in route i, p_j is the conditional probability (given a NOVA) the jth penalty is awarded, and PEN_j is the monetary equivalent of the jth penalty.

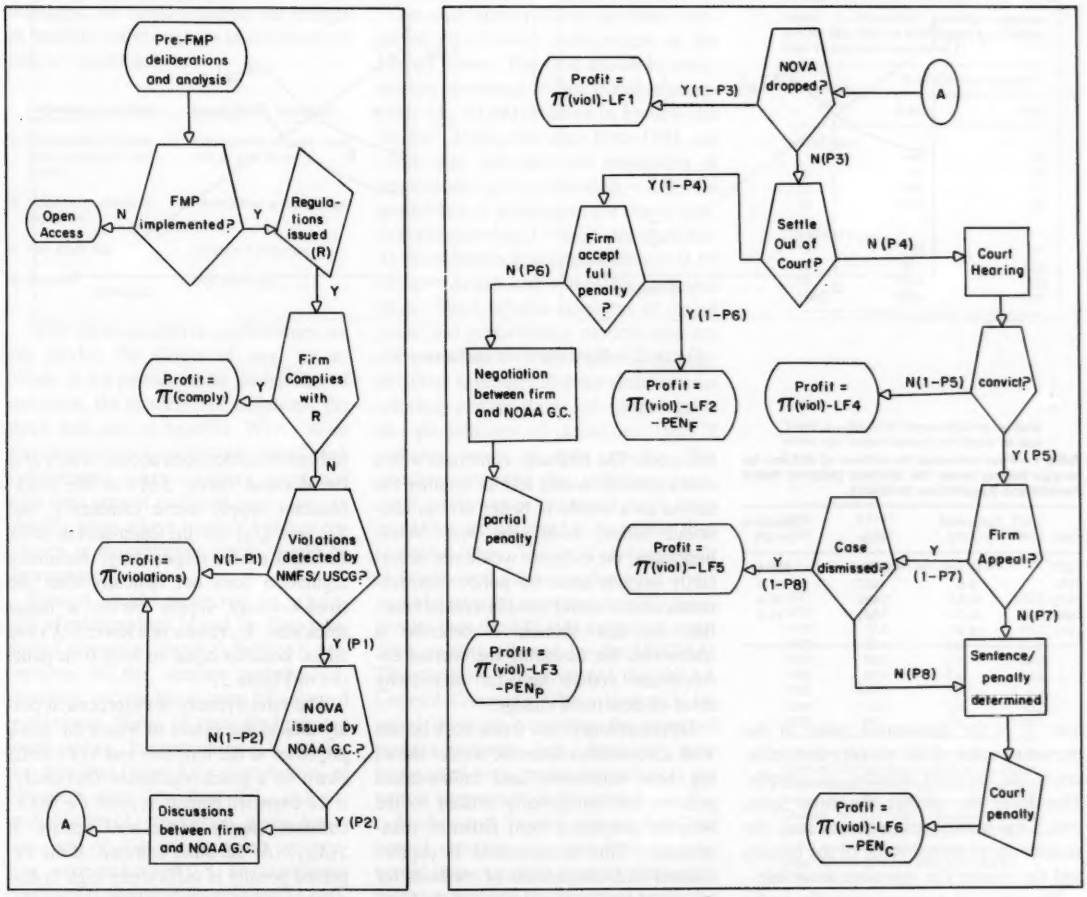

Figure1.—The decision-making environment for firms facing MFCMA regulations and enforcement actions.

Policy, Compliance and Benefits

The policy variables which affect the violate/comply decision are of three types: 1) the regulations, R; 2) the probabilities of detection, P_1, of prosecution (i.e., successfully issuing a NOVA) given detection, P_2;P_3, and of conviction or settlement; and 3) the penalites, $PEN(A)$. The regulations determine the extent to which activities of firms are constrained. The more constrained, the more likely firms will commit violations, other things constant.

The probabilities affect the magnitude of expected penalties and legal fees—the higher these probabilities, the higher the expected penalties and legal fees, and the less incentive to commit violations. The probability of detection is produced by inputs of sea and air patrols, observers, inspectors, and investigators (provided by the Coast Guard and National Marine Fisheries Service). Assuming efficient deployment, more of these inputs produces higher probabilities of detection. The probability of prosecution, given detection, is produced by the personnel who obtain the evidence and prepare the notices of violation (i.e., the field enforcement agents of NMFS and NOAA attorneys). The greater the quantity and quality of these personnel, the greater is this probability. The probability of conviction or settlement not only is enhanced by the greater quality and quantity of the NOAA attorneys, but is also mitigated by input of the defendant's attorney.

The magnitude of the penalties prescribed directly affects the magnitude of the expected penalty for a given violation. Other things constant, the more severe the penalties are, the more compliance there is with the regulations. The length of the time span from violation to collection of the penalty also is impor-

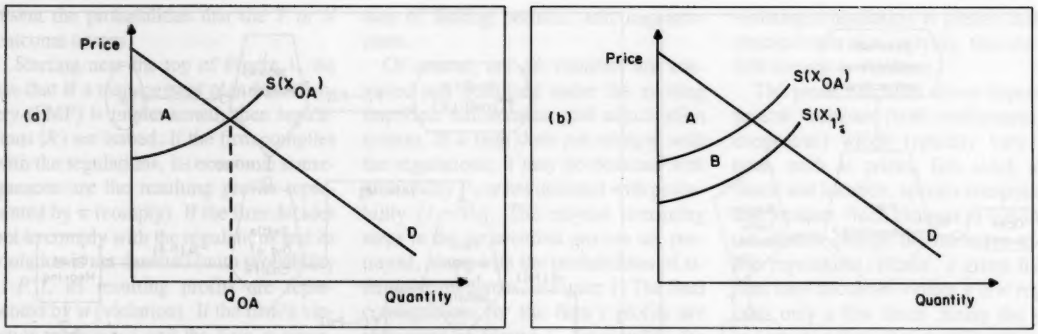

Figure 2.—Benefits from enforcement.

Table 1.—Fees collected (in millions of dollars) for foreign fishing under the MFCMA (Source: NMFS Permits and Regulations Division.).

Year	Collections ($\times 10^6$)	Year	Collections ($\times 10^6$)
1977	$7.1	1982	$33.4
1978	8.8	1983	41.3
1979	10.8	1984	42.9
1980	16.7	1985	41.5
1981	24.1		

tant. It is the discounted value of the monetary value of the penalty that influences the decision whether to comply. Therefore, the greater the time span, which has been years in some cases, the smaller the expected value of the penalty and the greater the incentive to violate.

The potential economic benefits to the country from MFCMA regulations and their enforcement consist of four types of benefits: 1) Counsumers' surplus, the benefits from consuming fish; 2) producers' surplus, the benefits from the commercial harvesting, processing, and sale of fish; 3) recreational benefits to anglers; and 4) Federal government revenue, the poundage fees paid by foreign fishing fleets.

We have no estimates of the first three types of benefits—consumers' and producers' surplus and recreational benefits (and I will not derive these estimates, since this is beyond the scope of this paper). The amount of government revenue from foreign fishing fees since 1977 is shown in Table 1.

Even if we had a reliable estimate of total benefits, it would have limited significance. The estimate, combined with a cost estimate, would tell us whether the nation as a whole is better off, in economic terms, under the Act. While important, the estimate would not necessarily suggest areas for policy improvements which would yield increased benefits. In this section I describe a framework for assessing the current enforcement system and for identifying areas of beneficial change.

Development of the framework begins with a somewhat heuristic model showing how regulatory and enforcement policies are functionally related to the benefits generated from fisheries management. This development is supplemented with discussions of methods for obtaining empirical estimates of the functional relationships which comprise the model. Let me deal only with the case of a fishery in the FCZ exploited solely by domestic commercial fishing vessels. The measure of total benefits in this case is the sum of producers' and consumers' surplus derived from the fishery.

As indicated above, the principal regulations implemented under the MFCMA have been total quotas, time-area closures, and gear restrictions. If effectively implemented, each of these measures would ultimately result in a larger stock size on average than would otherwise occur in an unregulated, open-access fishery.

This eventual increase in stock size generates added consumers' and producers' surplus, as shown in Figure 2. Area A in Figure 2 represents the annual flow of benefits under open access, where D is the demand curve, $S(X)$ is the stock-constant supply curve (Sutinen[5]), and X_{OA} and Q_{OA} are the open-access stock size and catch, respectively. Assuming regulation does not radically alter the stock-constant supply curve, a larger stock size, X_1, results in a lower $S(X)$ and added benefits equal to area B in panel (b) of Figure 2.

The effectiveness of enforcement policy affects the extent to which the stock increases in the long run and $S(X)$ shifts down for a given regulation. Obviously, if the expected penalty is zero, the stock-constant supply curve will remain at $S(X_{OA})$. At the other extreme, if the expected penalty is sufficiently high to dissuade anyone from violating a regulation, then the stock-constant supply curve would ultimately shift down to $S(X_T)$, where X_T is the target stock size resulting from complete compliance. (That the shape of $S(X)$ will change as regulations are enforced is ignored here.) Between these two extremes there is a direct relationship between the expected penalty and the long-run flow of benefits. That is, the larger the expected penalty, the fewer the violations, the larger the average stock size, and the greater the long-run flow of benefits from the fishery.

Therefore, if we had empirical estimates of the following quantitative rela-

[5]Sutinen, J. G. 1985. Notes on open access exploitation of a simple fishery. Mimeo. rep., unpubl.

tionships, we could compute the change in benefits due to changes in enforcement policy variables:

Dependent variables	Independent variables
1) Probabilities of detection, prosecution, conviction	Enforcement inputs (sea and air patrols, etc.)
2) Violation incidence by regulation	Probabilities and penalties
3) Fish stock size	Violation incidences
4) Benefits	Fish stock size

With these quantitive relationships we can predict the effects of, say, an increase in sea patrols on the probability of detection, the incidence of violations, the stock size, and on benefits. With similar estimates of marginal benefits for all such enforcement policy variables, combined with estimates of marginal costs, we can identify areas where increases and/or decreases in enforcement inputs would be appropriate.

Blewett, et al.[6] pioneered the estimation of relationships 1) and 2). They conducted surveys to obtain fishermen's perceptions of the various probabilities, penalties, and violation rates for selected regulations. Some of their findings are worth noting. In most cases (i.e., violation type and fishery) the probabilities of detection were less than 0.1, and the probabilities of prosecution, given detection, and of conviction, given prosecution, were each about 0.8. These separate conditional probabilities resulted in typical overall probabilities of conviction in the neighborhood of 0.06. With such low probabilities, it is not surprising that they also found the expected illegal gain exceeded the expected penalty in most cases. Their study also includes Ordinary Least Squares estimates of 2) for several cases, estimates which strongly support the basic paradigm described above.

No estimates of 3) and 4) were made by Blewett, et al.[6]. Still, their results proved useful for identifying weaknesses in the enforcement system and for guiding the reallocation of enforcement resources.

No such surveys have yet been completed on fisheries enforcement in the United States. The best available information pertaining to functional relationships 1) - 4) is contained in Frailey and Taylor[7]. Using case data from 1984 and 1985, they estimated the probability of prosecution given detection = 0.9, the probability of assessment (or conviction, in my terminology) = 0.95, the probability of collection given assessment = 0.85 for settled cases and = 0.50 for contested cases. Since reliable estimates of illegal gains and probabilities of detection are not available, they calculated the penalties necessary to deter violations for selected combinations of illegal gains and probabilities of detection. Table 2 presents some of their results. The penalties required for effective deterrence are lower in contested cases since legal fees are assumed to be higher than in settled cases. The most striking result of Frailey and Taylor[7] is that most of the required penalty amounts are many times greater than the $25,000 maximum monetary penalty allowed by the MFCMA. This analysis has prompted the NOAA General Counsel's Office to search for novel ways of increasing the expected penalty violators face. One way now being used with greater frequency is the permit suspension or revocation.

Frailey and Taylor[7] argued that "the permit sanction . . . can have an economic impact greater than the maximum monetary penalty we can assess under the statute." Unfortunately, fishing permits are not widely required in the fisheries regulated under the MFCMA.

The conclusion of this section should be clear. We know what information we need to assess fisheries enforcement policy and its effect on compliance and benefits, and we have methodologies for producing this information. But we do not have this information and we cannot yet say how well the Federal fisheries enforcement system is performing.

Enforcement Costs

In this section I attempt to examine the nature and magnitude of the costs of enforcing regulations under the MFCMA. The Act designates two Federal agencies to carry out enforcement of regulations: The National Marine Fisheries Service and the U.S. Coast Guard. The enforcement duties of these two agencies are primarily devoted to detecting violations of Fishery Management Plans and Preliminary Management Plans, with the Coast Guard conducting most of its surveillance at sea and NMFS acting onshore at dockside. The costs of their enforcement programs will be examined. Table 3 shows expenditures on fisheries law enforcement by the Coast Guard and NMFS since FY 1975. Prior to FY 1977, expenditures were entirely for enforcement of

Table 2.—Required penalty assessments ($1,000) as calculated by Frailey and Taylor (text footnote 7).

Illegal gain	Probability of detection	
	0.02	0.1
Settled case		
1	166	31
5	833	156
10	1666	312
15	2500	468
Contested case		
1	164	27
5	830	149
10	1664	300
15	2500	452

Table 3.—Federal expenditures on fisheries law enforcement (millions of dollars).[1]

FY	USCG	NMFS	Total
1975	$30.1[2]	$2.1	$32.2
1976	43.0[2]	2.3	45.3
--------- *MFCMA enacted* ---------			
1977	99.3	3.3	102.6
1978	87.7	4.1	91.8
1979	72.5	4.2	76.7
1980	52.4	5.2	57.6
1981	83.8	6.4	90.2
1982	86.8	6.8	93.6
1983	108.0	7.2	115.2
1984	105.3	7.6	112.9
1985	129.7	7.6	137.3

[1]Sources: Bell, F.W., and R. Surdi. 1979. An economic benefit-cost analysis of the Fishery Conservation and Management Act of 1976. Econ. Dep., Fla. State Univ., mimeo. rep.; Chapell, W. [Lt.] 1983. Personal commun.; and Peterson (1982), data for 1975-79. The U.S. Coast Guard and National Marine Fisheries Service provided data for 1983-85.
[2]Operating costs only.

[6]Blewett, E., W. Furlong, and P. Toews. 1985. Canada's experience in measuring the deterrent effect of fisheries law enforcement. Paper presented at the Workshop on Fisheries Law Enforcement, Univ. R.I., Oct. 1985.

[7]Frailey, M. H., and R. A. Taylor. 1986. Rationalizing sanctions for fisheries violations. Paper presented at the Conference on East Coast Fisheries Law and Policy, Univ. S. Maine, 18 June 1986.

other marine resource-related laws (e.g., the Marine Mammal Protection Act of 1972). The greatest expenditures are by the Coast Guard, reflecting the relatively high cost of air and sea patrols.

Individual states cooperate with NMFS to enforce the MFCMA, and their costs should be recognized. However, no data exist on the cost of states' contribution to the Act's enforcement. NOAA's General Counsel Office and the Administrative Law Court of the Department of Commerce prosecute the cases of violations of the Act. The expenditures of these two offices are small relative to the costs of the NMFS and Coast Guard programs and will not be examined.

In addition to government expenditures on enforcement, a complete discussion must examine the cost to the private sector of enforcement of the Act's regulations. While no data exist, an estimate is made of these costs.

Coast Guard Expenditures

By far the greatest expenditures on Federal fisheries law enforcement are by the Coast Guard, exceeding $100 million annually in recent years. The Coast Guard has several missions or programs. Enforcement of fisheries regulations under the MFCMA is included in the Enforcement of Laws and Treaties (ELT) program. Other programs include Search and Rescue, Drug Enforcement, Commercial Vessel Safety, Aid to Navigation, and Ice Breaking.

Table 4 presents a breakdown of the Coast Guard's expenditures on the ELT program for FY 1985. In addition to the MFCMA, the ELT program is concerned with enforcing the Marine Mammal Protection Act, the Lacey Act, and various fisheries treaties. The Coast Guard estimates that about 90 percent of its ELT program effort is devoted to enforcement of the MFCMA. Table 5 presents these estimates of expenditures for enforcing the MFCMA.

There are three major categories of expenditures by the Coast Guard: Operating Units, Direct Support, and Indirect Support. The expenditures on operating units include fuel, salaries, etc., for the vessels, aircraft, and shore facilities according to the amount of time each unit devoted to ELT during the year. These expenditures do not include amortized amounts for the acquisition (or replacement) cost of the vessels, aircraft, or other capital items. Direct support expenditures include district staff units, bases which provide repairs and maintenance, health care, and general administrative support. These amounts are provided by the head of each facility, who estimates the percent the facility's effort was directed to ELT matters. Indirect support expenditures include recruit training, public affairs, and alcohol rehabilitation programs. Again, percentage estimates of the extent to which each of these support activities contribute to the ELT program are used to calculate the resultant expenditures.

The estimated expenditures by the Coast Guard on MFCMA enforcement totaled about $117 million for fiscal 1985. Of this total, 61 percent was spent on operating units, 12 percent on direct support, and 27 percent on indirect support. I question whether indirect support expenditures should be a part of this total. Many of the indirect support activities appear to jointly serve all Coast Guard programs and are independent of the size and nature of any one program (e.g., MFCMA enforcement). To the extent this holds, changes in MFCMA enforcement activities do not affect indirect support expenditures. Therefore, these are not additional expenditures due to the existence of MFCMA enforcement. If this argument is valid, then expenditures total $85 million for fiscal 1985, instead of $117 million.

Just over two-thirds of the expenditures are attributed to enforcing MFCMA regulations on foreign fishing vessels ($80 million including indirect support, $58 million not including indirect support). Most of these expenditures were incurred patrolling the Bering Sea in the Alaska region.

The expenditures on domestic fisheries enforcement ($37 million or $27 million) were for the 25 FMP's in place during the year. A breakdown by region is not available.

Tables 4 and 5 include no expenditures or charges for the acquisition of the ships, boats, and aircraft used in fisheries enforcement. In cases where a craft is purchased and exclusively used for fisheries enforcement, then its capital cost should be amortized over time. In most cases, however, such craft serve several programs which leaves the problem of how to assign the capital cost to individual programs. The Coast Guard has chosen to assign none of these costs to fisheries enforcement. Therefore, the expenditures figures underestimate the costs of fisheries enforcement. The extent of this bias is not known at this time.

To what extent do the Coast Guard's expenditures represent costs to society? Unfortunately, the answer to this impor-

Table 4.—U.S. Coast Guard expenditures on enforcement of laws and treaties program, FY 1985 (millions of dollars).

Category	Foreign	Domestic	Totals
Operating units			
Vessels	$33.8	$13.3	$47.1
Aircraft	12.8	9.1	21.9
Shore facilities	7.8	2.1	9.9
Subtotal	$54.4	$24.5	$78.9
Direct support			
Administration	$2.0	$0.9	$2.9
Other	8.5	4.2	12.7
Subtotal	$10.5	$5.1	$15.6
Totals	$64.9	$29.6	$94.5
Indirect support	$23.9	$11.3	$35.2
Grand total	$88.8	$40.9	$129.7

Table 5.—Estimated Coast Guard expenditures on enforcement of MFCMA, FY 1985 (millions of dollars).

Category	Foreign	Domestic	Totals
Operating units			
Vessels			
Aircraft			
Shore facilities			
Subtotal	$49.0	$22.0	$71.0
Direct support			
Administration			
Other			
Subtotal	$9.4	$4.6	$14.0
Totals	$58.4	$26.6	$85.0
Indirect support	$21.5	$10.2	$31.7
Grand total	$79.9	$36.8	$116.7

tant question is ambiguous. For these expenditures to represent social costs, the following conditions must hold: 1) Fisheries enforcement is not a joint product of the Coast Guard, and 2) Coast Guard resources are allocated efficiently. A casual examination of the Coast Guard's enforcement operations suggests these conditions do not commonly hold. Therefore, we cannot say whether the above expenditures are roughly equivalent to social costs, or what direction the expenditure data may be biased.

Other Federal Expenditures

The expenditures on fisheries enforcement by other Federal agencies are small in comparison with those of the Coast Guard. The NMFS Enforcement Division spends about $7 million per year on the MFCMA, and the NOAA General Counsel Office and DOC's Administrative Law Court spend about $1.0 million annually.

Private Sector Costs

The regulation of industry has been shown to impose significant costs on the operations of business firms. Weidenbaum (1981) found for every dollar appropriated to operate Federal regulatory agencies there was an additional $20 of costs incurred by business to comply with the regulations. To my knowledge, the costs to the fishing industry of MFCMA regulations have not been estimated, but if the evidence from other regulation is any guide, these costs may be large indeed. The costs of complying with MFCMA regulations may include gear modifications and greater search costs, for example.

If detected of violating a regulation, the fishing firm may hire legal counsel and may have to take time off from fishing and lose income in order to deal with the NOVA against it. All such costs are social costs and should be accounted for in an evaluation of fisheries regulation and enforcement. The costs of fines, however, are merely transfers from the offender to the taxpayers and should not be included in an accounting of social costs.

How large might these defense-related costs be? Recent experience suggests about 300 NOVA's are issued annually to domestic fishermen for violating MFCMA violations. Let me assume that 1) the fees for legal counsel average $2,500 per NOVA, and 2) the income lost due to lost fishing time also averages $2,500. Under these assumptions, the added cost to the private sector of fisheries enforcement currently amounts to $1.5 million annually, or about 5 percent of what the Coast Guard spent on domestic MFCMA enforcement in 1985.

What can we conclude about the social costs of enforcing MFCMA regulations? First, the data are rough and incomplete. Second, the available data suggest these costs are significantly large. And third, the data have limited usefulness. As shown in the previous section, we currently have no measures of compliance, the principal product of enforcement, so we cannot assess the cost-effectiveness of the system. To answer a number of interesting policy issues we would need the functional relationships between the costs of various combinations of enforcement inputs and the probabilities of detection those inputs produce. Such relationships would, among other things, help guide improvements in the cost effectiveness of the enforcement system.

Conclusions

This paper has shown that only a few elements of a comprehensive cost-benefit analysis of MFCMA enforcement are currently available. The measures of aggregates costs, while not without problems, are relatively complete. Only one of the four types of benefits, foreign fees, is available. The functional relationships needed to support cost-benefit analyses of policy alternatives are not available. These will require additional data collection and extensive analysis and, therefore, are not likely to become available in the immediate future.

The available data do allow a partial cost-benefit analysis of enforcement efforts directed at foreign fishing operations. The Coast Guard's costs for enforcement related to foreign fishing activity totaled $80 million in FY 1985. Foreign fees collected totaled $41.5 million. Unless there are nearly $40 million of additional associated benefits to U.S. producers and consumers from foreign fishing in U.S. waters, these figures suggest the poundage fees for foreign fleets are too low, or there is too much enforcement devoted to foreign operations, or perhaps both. At the least, the formula used to compute foreign fee rates ought to be restructured to recover no less than the true costs of carrying out provisions of the MFCMA that pertain to foreign fishing.

Literature Cited

Becker, G. 1968. Crime and punishment: An economic approach. J. Polit. Econ. 76:169-217.

Peterson, A. E., Jr. 1982. Prepared statement in U.S. Congress, House of Representatives, Committee on Merchant Marine and Fisheries, Hearings before the Subcommittee on Coast Guard and Navigation, 97th Congress, 2nd Session (Ser. 97-26).

Stigler, G. 1970. The optimum enforcement of laws. J. Polit. Econ. 78:526-536.

Sutinen, J. G., and P. Andersen. 1985. The economics of fisheries law enforcement. Land Econ. 61(4):387-397.

Weidenbaum, M. L. 1981. Business, government and the public. Prentice-Hall, Inc., N.Y.

Young, O. 1979. Natural resources and the state. Univ. Calif. Press, Berkeley.

Enforcement of the MFCMA: An Economist's Perspective. Discussion

LOUIS J. GOODREAU

This paper is based on the same premise as the Regional Councils' FMP's, that enforcement is represented by the monies spent by the U.S. Coast Guard. It is believed that such enforcement is the most effective available for any given set of regulations. The argument is that, since the boats are out there anyway, they might as well be enforcing fisheries regulations. Concern for a blanket reduction of this enforcement coverage is well founded, and the recommended cost-benefit analysis should be required. Nevertheless, these factors will serve only to maintain the status quo, which for the past 10 years has been inadequate enforcement capability.

The New England Fishery Management Council finds that enforcement of fishery regulations is the weak link in the chain of fishery management. This is important whether the measures are operational controls such as the New England Council proposes, or limited entry such as the NMFS proposes. Neither type of measure can work without being enforced. Lack of enforcement results in uncertain benefits in the future, and makes incremental approaches to management like operational controls preferrable because the initial loss sustained is less.

It is the Coast Guard's at-sea enforcement capability with which we must be primarily concerned. The estimated $130 million spent by the Coast Guard is not the value of enforcement. In fact, and with good reason, other tasks such as safety, rescue, and drug interdiction take wide precedence over fishery enforcement. The marginal improvement in fishery benefits for a cutter day at sea or a 1-hour overflight not only are unmeasured, they virtually do not exist. Rather, what is needed is an increase in the quality of these days. For instance, more violations were issued in 1986 by the Coast Guard (almost as much as in the previous 5 years) during a period when the number of cutter days was halved. If the Coast Guard were required to give up the portion of its budget actually used for fishery enforcement and maintain the same level of coverge for all its other tasks, the amount available for enforcement would fall far short of $130 million. Correspondingly, if an independent entity were charged with fishery enforcement and given enough funds to adequately enforce current regulations, the budget would probably also fall far short of $130 million.

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Policy, Compliance and Benefits

In this section the author discusses the importance of a direct relationship between the expected penalty and the long-run flow of benefits. However, because estimates of illegal gains and probabilities of detection are not available, penalties necessary to deter violations are calculated for selected combinations of illegal gains and probabilities of detection (Frailey and Taylor, footnote 7). The result is that the required penalty amounts are many times greater than the $25,000 maximum monetary penalty allowed by the FCMA, and the recommendation is for permit sanctions. Two other avenues may help, concentrating on the area of least coverage: 1) Increasing the probability of detection, through improved quality of Coast Guard boardings and developing the inshore fleet, and 2) making each $1,000 worth of illegal gain a unique violation, each liable to a $25,000 fine.

It makes economic sense to expense the cost of enforcement up to the level of expected benefits of an FMP, i.e., if benefits of a given regulations are worth $100,000 per year, then we should be willing to spend up to $100,000 to enforce them. In practice, we should at least be expensing a minimum proportion of the expected benefits for each regulation implemented, say, 10 percent. These funds could be used to supply fuel for small inshore enforcement fleet interceptions, such as Coast Guard boats that are currently not involved, which would be much more cost effective than $26,000 cutter days (which require at least two violations at $25,000 for each day at sea to be cost effective) with only two high-endurance cutters being used out of a total of 29 cutters.

Enforcement Costs

Fisheries enforcement by the Coast Guard is indeed a joint product. What is needed is fisheries enforcement as an entirely separate program, such that the expenditures are an appropriate measure of the social cost of the resources used. Otherwise, following the reasoning on page 42 relative to the multimission of the Coast Guard, estimated expenditures for FMP's which Councils regularly receive for the more valuable fisheries should be an overestimate of the social cost of these resources, relative to the FMP's for the less valuable fisheries.

Two-thirds of the Coast Guard's fishery enforcement expenditures goes toward foreign vessels. This leads one to question whether the elimination of foreign fishing may be justified, based solely on the improved realization of benefits from domestic fishery regulations if all of those enforcement resources were diverted towards domestic vessels.

Interdependencies Among Fisheries Management, Fisheries Trade, and Fisheries Development: Experiences with Extended Jurisdiction

RICHARD S. JOHNSTON and JAMES R. WILSON

Passage of the Magnuson Fisheries Conservation and Management Act (MFCMA) brought with it much speculation about its likely impacts on fisheries production and seafood trade. There were those who hoped that the Act would propel the United States into the ranks of the world fishing and seafood exporting powers, largely because of the immense resource base that apparently was brought under U.S. control. Subsequent refinements of the Act, however, represent a recognition that such control did not necessarily translate immediately into the development of this base. Provisions for foreign fishing and joint venture arrangements were included to satisfy world political realities as well as to accommodate needs of the domestic fishing sector. In all, the Magnuson Act appears to be as much an experiment in fisheries development as it is in fisheries management.

Moreover, the importance of the Act, perceived in a global context and from an historical perspective, pales considerably when compared with world trends. The global impacts of the Truman Proclamation of 1945 lay the foundation not only for the Magnuson Act, but also for many similar acts and declarations worldwide. Between 1945 and the late 1970's, claims to different parts of the ocean resource zones were declared by other countries. One could argue that the Truman Proclamation brought on the trend of extended jurisdiction (EJ), and that the trend has simply been accelerated by the MFCMA. Presently, practically every maritime nation has made a claim to a Fisheries Conservation Zone (FCZ) or an Exclusive Economic Zone (EEZ).

It is also important to note that these new resource claims have been made by a number of relatively new nations in the wake of the postwar trends in the growth of independent nation-states. This growth of nation-states, which has occurred coincidentally with (and was probably the major fuel for) extended jurisdiction, has in turn fueled an impressive growth in naval arms trade, apparently in an effort to exercise real control over the claimed rights to the FCZ/EEZ's (Morris 1986; Wilson and Morris[1]). For many of these countries, fisheries management and enforcement has become a new responsibility.

This paper discusses this new environment and what it means for the development and management of U.S. fisheries resources, with particular reference to international trade. Specifically, we present two views regarding extended jurisdiction which we believe should be considered to understand policy positions on both international fishing and seafood trade issues.

First, we argue that the strength of a nation's property rights over a resource endowment will determine, to a considerable extent, what will be traded. In particular, a resource base claimed by a nation may be utilized in many ways, depending upon the strength of rights and the costs of other productive inputs, to form a large number of intermediate goods. Other countries may be strong competitors with the United States in the production of intermediate goods and their decisions may affect the management and development policies which we take as a nation. As in agriculture, our potential competitors may turn out to be quite formidable.

Our second point is that to produce reasonable policy for fisheries, an understanding of uncontrollable but highly influential events exogenous to the fisheries sector is of paramount importance. Although the global EJ trend is important, other factors are also driving both fisheries and the other sectors of our economy. We hypothesize that, in the formation of new fisheries policy, due consideration will be given to the comparative roles of these different effects, such as global macroeconomic trends. We discuss each of these points in turn.

A Property Rights Approach to Trade

There is a theoretical basis, as well as a casual empirical basis, for stating that the structure of property rights, as reflected in institutions, is codetermined with both the level of production within a country and the types of goods traded. These rights are based upon a combination of international customary law and the level of defense expenditure and capability. What the country decides to produce and trade is also a reflection of the cost of inputs necessary to the transformation of natural resource bases and of the preferences of the society. For these reasons, it is not likely that the trade envi-

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[1]Wilson, J. R. and M. Morris. 1986. The role of defense in the formation and maintenance of property rights: Extended jurisdiction and the Third World. Working pap., 11 p.

ronment for a product such as fish can be completely characterized by looking at the trade statistics for fish. In fact, trade in a number of instruments used in the production of fish can be seen in the world today. Some of these trades may never show up in a balance of payments account. For example, a cash-poor country, with limited access to exploitation technology and with a relatively high cost of capital, may well be attracted to the prospect of being able to sell some intermediate good to avoid investment in either expensive capital or defense and enforcement. For this reason, it seems worthwhile to investigate ways to incorporate the notions of property rights into the discussion of the trade impacts of EJ.

Coastal nations that extend their fisheries jurisdiction can be viewed as having experienced an increase in resources and, hence, increased production possibilities. Conversely, nations whose distant-water fleets no longer have access to fishing grounds now under the jurisdiction of another nation, experience a reduction in production possibilities. The resulting impact on trade could be examined in a manner similar to the way one would analyze the trade impact of economic growth (Batra, 1973; Chacholiades, 1978). Indeed this was done recently by Johnston and Siaway (1985).

However this approach begs an important question. Does the declaration of extended jurisdiction necessarily provide all countries with the same level of ownership of the associated resources and, thus, the same opportunity to exploit fully those resources? We suggest that it does not, and that many of the trading arrangements (e.g., different kinds of joint venture structures) can best be understood by viewing ownership not as something a country has or does not have but, rather, as something held with various degrees of strength. Whether a newly endowed country harvests and sells fish, or sells the "right" to fish, or selects some other resource use alternative is importantly determined by the cost of defining and protecting property rights in the new territory.

Thus it is important to look carefully at the notion of property rights. According to one definition, "A person's private property rights are the expectation that what one decides to do with certain resources will be effectively carried out, or realized" (Alchian and Allen, 1968:98).

Consider the implications of this statement. A person or a nation will possess a right which is conceded to it by the community. For example, rights of "free speech" at the individual level and "rights to impose tariffs" on traded goods at the nation-state level can be strengthened or abridged by the actions of the community at large. However, individuals or nation-states may also possess varying strengths of rights by the maintenance of a threat through, say, defense and enforcement (D&E) expenditure. A combination of community concession and expenditures on D&E constitutes the full complement of ways in which expectations (property rights) are maintained.

We find it useful to think of ownership of a resource in these terms; that is, in terms of the strength of the associated property rights, ranging from weak ownership to strong ownership. The Alchian and Allen (1968) definition allows us to consider the relationship between property rights and institutional arrangements, or claims. A change in institutional arangements, such as EJ, may or may not affect the actual property rights of a nation. This will depend on how expectations change and on what happens to the variance of expected outcomes. It is important to recognize, however, that D&E constitutes, in most realistic situations, a necessary part of rights maintenance. The possession of different strengths of property rights allows different types of activities to take place. Weak rights, or those given by concession, may entitle the nation to a limited range of activities. Stronger rights allow the disposal of resources over a wider range of activities.

Viewed this way, much of the international trade activity following extended jurisdiction can be seen to involve the exchange of bundles of goods and services, including services associated with different levels of property rights. Looking only at data on international trade in fish following EJ may obscure important economic relationships. Our discussion is an extension of the analysis by Sutinen and Anderson (1985), who argue that "the cost of defining and securing exclusive property rights under the new extended jurisdiction regime, is a principal determinant of management measures that eventually will emerge. Thus the presence of enforcement costs may have a significant impact on fish production and allocation in the future as coastal states move to regulate fishing activity in their waters."

We extend this insight to embrace trade. That is, we permit the buying and selling of policing (D&E) activities among countries. A country with new resources to manage and exploit could contract with enforcement agencies—perhaps in another country—to police use of its resources. These D&E—or fisheries management—services could be provided by a country other than the one prosecuting the fishery. However, since "effort" and policing activities are complementary inputs in the harvesting of fish, efficiency may be realized by combining these activities. Thus, as shown below, the decision on how much and whose effort to use in a fishery is simultaneously a decision about the strength of property rights in that fishery. The use of zero policing services, for example, and the resulting "open access" solution is the decision to allow weak property rights to prevail in the fishing zone. Conversely, the extensive use of policing services and the resulting "rationalized" fishery is the decision that strong property rights will prevail. Most arrangements probably lie between these extremes. When a coastal nation imports policing services through the distant-water fleets of other countries or through joint-venture arrangements it is participating in international trade involving fish, fishing rights, harvesting services, and policing services, variously bundled.

Thus, we also extend the notion of Munro (1985) that "if a coastal state enters into a cooperative fisheries arrangement, one can think of the coastal state as importing harvesting and/or processing services from a distant water nation(s)." Specifically, we add policing services—they may simply take the form of self-policing agreements because a distant-water, rent-seeking fleet may require fewer policing services than would have to be provided by the coastal country—to the packages of goods and services being

traded among international participants in the fishery.

Consider this with the use of diagrams. If we look at the relationship between the production of goods and services[2] and the expenditure of D&E in a country, we can visualize a trade-off curve that has an area of increasing returns to D&E (Fig. 1). This is reasonable: A certain expenditure of factors in the form of D&E not only secures the possible use of productive factors, but also creates an environment conducive to enhanced production. Beyond E', additional inputs of D&E can be produced only by giving up production of other goods. If we assume the existence of community preferences for illustration purposes, and think of D&E as a public "bad" (a necessary evil) or as input used in the production of the other goods, then I is the highest community indifference curve achievable, and the country is at equilibrium at T^*, E^*. The uncontested portion of productivity would be OA. The part which would have to be maintained through D&E is AT^*.

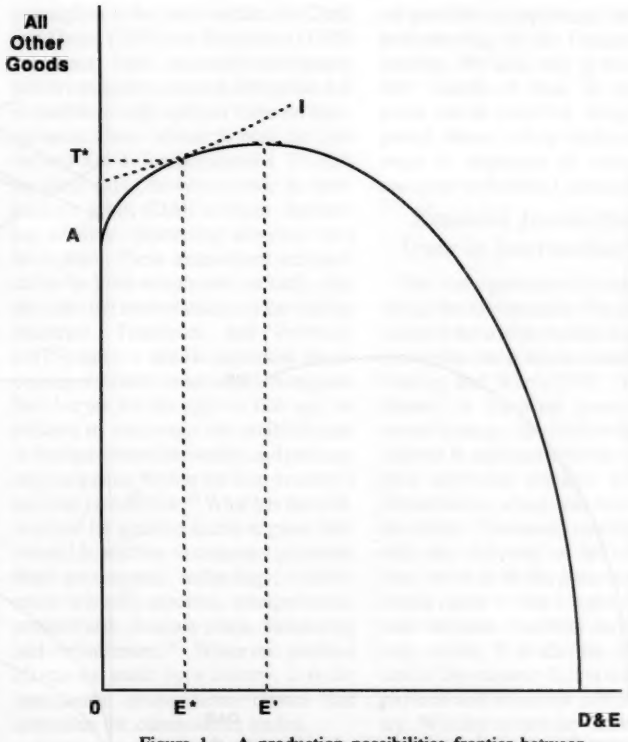

Figure 1.—A production possibilities frontier between D&E and all other goods, and the equilibrium conditions that will prevail.

However, D&E expenditures are made, in general, to strengthen or maintain property rights, as we have discussed. This leads us to argue for a reconsideration of the notion of comparative advantage. Economists generally tend to think of comparative advantage under conditions in which all factors of production have strong property rights attached to them. In general, it is further assumed that these rights are costless to maintain. However, in reality, many resource rights are imperfectly defined or weak. Resources in the fishery are simply one example of this. Furthermore, even the maintenance of relatively weak rights is often costly. Under such circumstances, production, trade, and property rights decisions are made jointly.

For example, consider two countries: A, with a new EEZ, and B, with a distant-water fleet. These two countries, because of the uncertainty in dealing with each other, keep a certain amount of their endowments in defense and enforcement. In addition there exist a number of rules and agreements. Together these activities form the basis of the relative property rights strengths between A and B[3]. That is, for any productive claim, the strength of the rights a country has on that claim depends upon 1) the degree of recognition of the claim by "the world community" and 2) the level of D&E activity in which the country engages[4].

Thus, the "strength of property rights" in a resource can be viewed as an argument of the production function associated with that resource. For a given set of (negotiated) rules (no. 1 above)[5], we can visualize a one-to-one mapping between the expenditure of resources for D&E and the strength of property rights (Fig. 2). Increased D&E expenditures are likely to lead to increased strength of property rights, although such a positive relationship is unlikely to exist for all D&E levels. The precise nature of the relationship is determined in part by the level of negotiation, which is again a function of the

[2]To avoid the use of three dimensional diagrams (we would need them if the strength of property rights were considered explicitly), we will assume that an "increase in all other goods" means an increase in the physical volume of other goods, the services of which are defined for a given level of property rights.

[3]For further discussion of negotiated rules and defended rights see Sutinen and Andersen (1985) and J. R. Wilson (1984), The history of extended jurisdiction: Property rights formation and anarchy. Pap. in unpubl. dissert. "Some consequences of extending ocean resource zones."

[4]A certain portion of these claims will have no need of enforcement and defense. For example, in the case of EJ, it may be mutually agreed that permission and guest allocations must be given to visiting fishermen before they can fish.

[5]The authors recognize that for a truly comprehensive look at the relationship between the strength of rights and trade one would have to account for the reasons that negotiation does (does not) occur, and the determinants for decisions to expend valuable resource on negotiated settlements. Explicit treatment of this issue is beyond the scope of this paper, however.

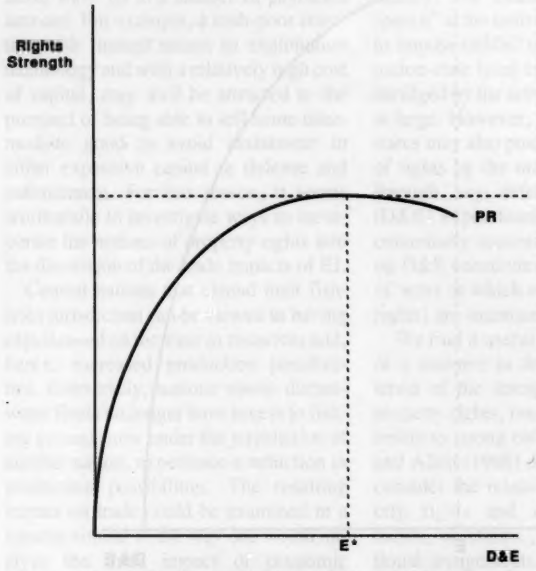

Figure 2.—A production relationship between the strength of property rights (*PR*) and expenditures on defense and enforcement (D&E).

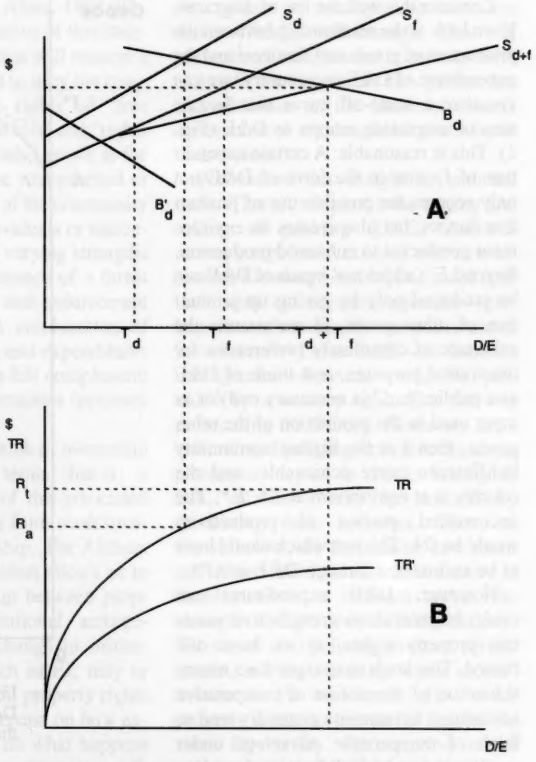

Figure 3.—Allocation of policing services between foreign and domestic participants in a fishery.

country's endowments. However, it is likely that, throughout some range of D&E expenditures, the marginal return to increased D&E expenditures declines, and beyond some level (E^* in Figure 2) it is negative. Now if B's fleet fishes in A's waters, there will be division of domestic D&E and foreign D&E. A portion of the D&E supplied by the foreign nation is actually the degree of "recognition" of A's claim, which A subsequently does not have to enforce. In the case of policing its own fleet and the activities of third parties (country C), provision of D&E may involve actual resource outlays by B.

In Figure 3A, S_d and S_f represent the supply of policing services (D&E) by country A (domestic) and country B (foreign), respectively. Curve B_d represents the marginal benefits associated with different levels of D&E expenditures.[6] Total benefits (TR) are given in Figure 3B. The intersection of S_d and B_d is A's autarky position, with a total revenue of R_a. Since A seeks to maximize benefits to the nation, however, the decision makers will select that mix of foreign and domestic D&E expenditures which achieves this. Curve S_{d+f} is drawn to "equate" the marginal costs of domestic and foreign policing. In equilibrium, T_d units will be supplied by the domestic country, T_f will be "imported"[7], and R_t revenues are generated. This solution is country A's policy regarding foreign and domestic use of A's fishing zone. It may, for example, describe a joint venture policy under which the foreign partner provides processing services and determines the amount of effort to be devoted to harvesting, perhaps by the domestic fleet. Polic-

[6]The relationship may be thought of as follows: As D&E expenditures increase, so does the strength of property rights, at least over some range. This increases the rent that the fishery resource may earn, up to some maximum. For example, in the standard, static bioeconomic model, a reduction of effort from its open access level leads to rent increases, up to that associated with maximum economic yield. Increases in D&E expenditures may strengthen property rights and lead to increased ability to reduce effort levels. Thus, curve B_d in Figure 3A may be viewed as a relationship between marginal resource rents and D&E expenditures. In a sense, then, expenditures on D&E may be regarded as expenditures on fisheries management.

[7]From Country B. The analysis could be extended to include all foreign countries.

ing of harvest, then, is done by the foreign partner (T_f) and the domestic partner may, through its own policing activities (T_d), prevent third parties (countries or other domestic harvesters) from prosecuting the fishery. Country A, then, exports a bundle of goods and services that includes fish, harvesting activity, and D&E services. Country B may, for its part, export a bundle consisting of processed fish, processing services, D&E services, etc.—essentially a barter transaction—and/or may make direct payment for imports (e.g., rental payments for joint venture participation; payments to fishermen). This is a quantitatively and qualitatively different trade solution than the result associated with, say, country A's selling the right to fish (in exchange for a royalty) to country B.[8] However, a simple inspection of fish trade data would not reveal this as there is no reason to believe that the quantity of fish actually delivered to country B under the two arrangements is different. Indeed any of a large number of solutions is possible and the difficulty with using the standard trade model to analyze them is that, in that model, the strength of property rights is determined outside of the system. Here, however, we are arguing for treating it endogenously.[9,10]

Thus we are led to conclude that there is a strong link between fisheries management and seafood trade, and that this link has become more clear with extended fisheries jurisdiction. Samples (1985) outlines the contractual terms of two international tuna joint ventures in the southwest Pacific in which the host countries granted sole rights (ranging from harvest rights to processing and export rights) to the joint venture. As Clark and Munro (1980) and Hannesson (1985) point out, such monopoly/monopsony power can lead to resource utilization that is consistent with optimal fisheries management. Gains accrue to both the host country and its foreign partners. To realize these gains, however, trade in intermediate goods (D&E services, harvesting services, processing services, etc.) takes place. These transactions are internal to the joint venture and, as such, may not enter the trade statistics of the trading countries. Tomlinson and Vertinsky (1975) make a similar argument for licensing schemes under which foreigners are charged for the right to fish and for policies to encourage the establishment of foreign-owned harvesting and processing companies within the host country's national jurisdiction.[11] What has the U.S. received for granting access to guest fishermen? In addition to monetary payments there are data sets, technology, collaborative scientific research, semiprocessed product and, in some cases, monitoring and enforcement.[12] Whatever nominal claims are made by a country, it is the institutional arrangements chosen that determine the commodities traded.

Joint venture catches by U.S. flag vessels rose from 10,600 to 911,200 metric tons between 1979 and 1985 (NMFS, 1986). These "exports" took place under different property rights arrangements than did the exports of seafoods through more "traditional" marketing channels. As public policy regarding management of the U.S. FCZ unfolds, these arrangements will change and be accompanied by shifts in trade patterns. Property rights and trade are intimately linked. The fishery provides an opportunity for improved understanding of this fundamental relationship. We look next at how some recent models of trade in intermediate goods can be modified, along lines suggested above, to help explain the differences in responses of various coastal countries to extended jurisdiction.

Extended Jurisdiction and Trade in Intermediate Goods

The consequences of a country shouldering the development of a newly found resource have been studied in detail, with one of the more recent contributions by Cassing and Warr (1985). The "Dutch disease" is the name given to the observed contraction of other domestic industries in adjustment to the needs to exploit newfound resource wealth. This phenomenon, which was first seen in the developed European countries shortly after the discovery of oil in the North Sea, seems to be the practical result of a strong rights system coupled with large-scale resource discovery and attempts at exploitation. It is also the result of the size of the resource find in relation to the physical and economic size of the country. Whether or not the "Dutch disease" sets in may be determined by barriers to the inflow of foreign capital.

As Cassing and Warr (1985) note, the disease can be brought on by restrictions in the flow of productive inputs into a country from foreign sources. Conversely, its effects can be dampened by the encouragement of these types of enterprises. This discussion may be of little direct interest to managers of the U.S. fisheries sector, since the U.S. is unlikely to be affected by the "disease" in the course of developing its fisheries in the wake of EJ.

However, the likely resource supply competitors of the world, the developing countries, confront this routinely as a real policy problem which must be addressed in the course of their own country development. That is, for a country which is relatively undiversified, militarily weak, and small, the EJ claim can be the beginning of a difficult balancing act between D&E expenditures, access to necessary technology, and the satisfaction of employment and other development objectives within the country.

[8]Suppose, in Figure 3, that the relevant total revenue curve is TR', not TR, and that the associated marginal benefit curve is B_d'. It does not pay country A to participate directly in utilization of its fishing zone.

[9]Suppose that, in Figure 3A, curve S_f were the domestic supply of policing services and S_d were the foreign supply. Suppose, further, that TR' were the relevant total benefits curve with B_d' its marginal counterpart. In this case, there are strong incentives for a purely domestic fishery, with no direct foreign participation. This may be the case for the United States.

[10]As Doug Lipton argues in his discussion, the model can be extended to include elements of imperfect competition. This is a potentially fruitful area for further analysis.

[11]With respect to joint ventures, Tomlinson and Vertinsky (1975) argue that "one of the problems in policing the new coastal limits for nations without a naval tradition will be the lack of effective domestic deterrent ability" and that "control of sufficient (military) force. . .to exercise sovereign rights. . .(and). . .access to adequate information to apply such force in time for it to take effect. . .will be enhanced by local participation in fishery joint ventures." We suggest that, with long term contracts (Samples (1985) describes 10-year contracts, subject to renewal), some joint venture arrangements provide incentives for the foreign participant to provide the policing services.

[12]Although, in most cases, this has been part of the package exported.

As Svejnar and Smith (1984) relate, most developing countries have long wrestled with the issue of appropriate institutions for "indigenization" of production. The observations of these and other authors suggest the existence of a "scale" of productive involvement by a country, ranging from the simple licensing of a transnational corporation to the largely domestic production found in more diversified countries. As more bargaining power ("perceived rights") is acquired, these countries seek to avoid many of the negative impacts that are present in some of the more "primitive" business arrangements. However, the realization of this objective must be balanced against the negative impacts of isolationist development policies. Therefore, a whole range of institutional relationships can arise, each of which is associated with a different level of property rights. The trick for the leaders of the country, however, is to choose a D&E investment which will not only match the resources of the country with the requisite productive inputs, but also the needs of the country. To this end, there has been considerable interest not only in the conventional forms of resource developments and trade, but also in less conventional forms such as barter and counter-trade as discussed earlier.[13]

Sarkar (1985) has investigated the implications of differential rates of time preference across countries on the pattern of trade in intermediate goods, by allowing trade at every point on the productive spectrum. The testable hypothesis deriving from his model is that those countries for which the cost of capital is relatively high tend to specialize in those processes which require relatively less capital. Hence, less developed countries with lower wage rates but relatively high capital costs specialize in the production and export of intermediate goods on the low end of the productive spectrum. They thus avoid having to "hold the goods in process for the entire productive spectrum." (Sarkar, 1985:86).

Sarkar's economy is characterized by a sector in which each successive stage of production from raw material to final consumer good is an input to a subsequent stage of production. Suppose this sector is the fisheries sector. Suppose, further, that the output of each process requires D&E services, to which it exhibits diminishing marginal productivity. Then, allocation of D&E between a host country and its foreign partners[14] determines the level of tradable production.

With the advent of extended jurisdiction, D&E activity in the waters of coastal nations acquired increased legitimacy in the international community and, thus, the property rights of coastal countries could be strengthened by their use. Production possibilities for those countries increased, as suggested above. Thus, D&E expenditure raises the possibility of greater diversification within the coastal zone and raises productivity there. Productive factors are drawn from other sectors, resulting in production and trade of intermediate goods closer to the final stages of production. On the other hand, countries for which D&E services are costly to produce may become aggressive traders in the more primary focus of fisheries: Fishing access and raw product.[15] This is undoubtedly the case for many of the developing coastal countries.

There has been a growth of independent third-world states since the beginning of the twentieth century. Between 1943 and 1981, 94 newly independent nations emerged. These new nations are just beginning to make significant impacts in agriculture, light industry, and even heavy industry. Many, however, are extremely poor. Extended jurisdiction undoubtedly gained considerable impetus from the desire to broaden natural resource bases by both these countries and the developed countries. In this milieu, the United States exerted jurisdiction over the resources of the seabed of the continental shelf, then over fisheries resources, and finally declared an EEZ. The United States, through the Magnuson Act, has embarked upon a careful development plan to do away gradually with foreign fishing activity in the EEZ, and to domesticate completely all stages of fishing and processing activities. We believe that consideration of the several issues raised in this and the previous section would greatly enhance future discussions of U.S. fisheries policy.

For example, U.S. fisheries trade involves two major groups (government and the private sector) and several interrelated markets. Two big U.S. markets are the access market and the raw product/JV market. In some dealings, it is unclear what is being traded. The bundle could include trade concessions on unrelated U.S. exports. However, by attempting to assert strong property rights the government may be changing the relevant trading bundle and, thus, the terms of trade. This may cause former guests to go on a search for, and develpment of, fisheries in other nations. If guest fishing nations are able to find low cost of access within developing nations, for reasons described above, then their competitiveness should not be substantially diminished by the U.S. phase-out. On the other hand, U.S. producers, constrained in the purchase and use of foreign hulls and by an expensive ship-building industry, and shut off from ready-made JV markets, may be fighting an uphill battle to stay ahead of the other world fishing powers.

In addition, fisheries management has long enjoyed access to relatively high quality data on catch and effort generated by guest fishing nations. The assertion of stronger property rights will erode this

[13]Banks (1985) argues that these newer methods of trade are becoming popular because "surplus commodities" exist, largely as a result of artificially constrained markets created by government policy. He cites three main sources or rationale for barter activity: Domestic price controls, international price controls, and exchange controls. However, we believe Banks leaves out an important reason for barter and counter-trade. Newly found resource wealth in countries constrained by capital scarcity forces the consideration of nonconventional trade arrangements which, from the standpoint of standard trade practice, make little sense. However, if the notion of strength of rights is incorporated in the problem the basis for these policies is clear. While it may well be that barter and counter-trade is a second-best policy for many countries, a number of nations, including firms in the United States, have used these methods to their (apparent) advantage. The existence of barter clauses in joint-venture arrangements between U.S. and foreign entities is somewhat indicative that alternatives to conventional trade, even for some U.S. firms, has been fruitfully used in conjunction with other arrangements.

[14]This will, of course, depend on relative input and output prices, as well as the technical relationships among D&E services, intermediate products, and final goods.

[15]For noneconomic reasons, investment in D&E may enter the substitution range of the production possibilities set. This can act as an effective constraint on resource development.

data base, and the rights of data access now will have to be renegotiated with domestic fishermen. This is potentially an important consideration, since a substantial amount of data, and necessary infrastructure for collecting these data, was developed through long association with the guest nations. In a sense, trade took place in scientific information for fisheries managers as well as in access to fisheries. Fisheries managers may well lose part of that component which they previously had by trade associations.

U.S. fishermen may eventually consider the prospect of engaging in multinational operations which take advantage of their skills at harvesting coupled with low costs of entry and efficient processing technologies. This could mean teaming up with a foreign factory ship and guest fishing on productive grounds off the coasts of developing nations. Finally, fisheries development in other countries with an eye towards improving access has long been employed by other nations as a means of taking advantage of opportunities that exist for trade. The U.S. industry may find this option attractive. In other words, EJ could conceivably offer possibilities for fishermen and processors beyond the U.S. EEZ. If U.S. fisheries policy does place the industry at a disadvantage in the world market, then a logical response of the industry might be to draw raw product from cheaper sources. In summary, Americanization, while a popular policy, may have the effect of turning the industry inward and encouraging an air of complacence. It might, however, be auspicious for that industry to continue expanding its world view for opportunities in fisheries production and trade.

To this point we have focused on events within the fisheries sector. In the next section we briefly examine the second thesis of this paper: Namely, that events outside of the fisheries sector are important in understanding seafood trade[16].

Seafood Trade and Macroeconomic Factors

We have argued that analysis of the relationship between seafood trade and extended fisheries jurisdiction may lead to a misunderstanding of underlying economic processes if decisions about the strength of property rights associated with harvesting are not considered explicitly. However, even in the absence of this consideration, there is another difficulty associated with focusing on the impacts of extended jurisdiction on seafood trade: Failure to consider the role of events outside of the fisheries sector.

As indicated above, one could view extended fisheries jurisdiction as a global reallocation of ownership of the ocean's resources. We have suggested that the issue is more complex than this. Even if it weren't, however, there are some characteristics of the fisheries resource that merit special treatment. Consider, first, the relationship between seafood trade and real economic activity.

Seafood Trade and Real Economic Activity

Economists argue that international trade and domestic trade merit different treatments (and models) because factors of production are less mobile among countries than within countries (Caves and Jones, 1973) and because public policies affect trade among countries differently than trade within countries (Lindert and Kindleberger, 1982). But suppose changes occur in the geographical boundaries of the world's nations. The numbers appearing in the international trade data of the world could be dramatically affected by a globally accepted declaration of sovereignty by each of the 50 states of the United States, the 10 provinces of Canada, or the 32 states of Mexico. Shipments of California oranges to Michigan or of British Columbia salmon to Ontario would become international, instead of interregional, transactions. Apparent, as opposed to real, increases in economic activity could thus be generated by a shift in national boundaries[17]. One could argue that such a shift has taken place in the ownership of the world's oceans. It is important to distinguish between resulting changes in the level and nature of real economic activity and a simple relabeling of existing activities[18].

While extended fishery jurisdiction has not yet resulted in massive territorial expansion, the almost universal acceptance of the fishery management authority of coastal states (albeit not without conflict; Jacobson, 1980) effectively redistributes access to the living resources of the world's oceans. Has economic activity increased with extended jurisdiction? Between 1976 and 1982, the volume of seafood traded internationally rose about 27 percent (FAO, 1984)[19]. During that same period, the world harvest of fish, crustaceans, and mollusks increased about 7.5 percent (FAO, 1984). Thus, world seafood trade increased considerably more than did world seafood production. It is likely, then, that some of the increased trade represents a redistribution of, rather than a global increase in, economic activity[20].

In addition, some of the increased trade activity in seafood may have resulted more from phenomena outside of the fisheries sector, phenomena which were independent of extended fisheries jurisdiction. The analysis by Johnston and Siaway (1985) suggests that increased international seafood trade would have occurred even without extended fisheries jurisdiction, because of changes in global economic conditions. These authors argue further that the effects of this major development in the ownership of

[16]The discussion that follows draws heavily on Johnston and Siaway (1985) and on R. S. Johnston (1984), Status and trends in seafood trade. Unpubl. pap. pres. at Eighth Annu. Sem., Cent. Oceans Law Pol., Univ. Va.

[17]In the long run and in the presence of perfect markets. Short-run decisions could be affected because of adjustments to the new institutional arrangements. Further, new, administratively determined levels of factor mobility may introduce new constraints on the operation of markets and, hence, affect the levels of real economic activity.

[18]When new resource discoveries are made (e.g., oil deposits) in a country, one would, under circumstances favorable to the utilization of those resources, expect an increase in that country's economic activity and, as a result, an increase in worldwide economic activity. It is not clear that such increases would necessarily accompany a redistribution of the existing stock of resources among the various countries of the world.

[19]These figures pertain to product weight and to the 158 countries covered by the FAO data. While there are aggregation problems associated with using product weight to measure trade volume, they are probably less severe than those associated with the corresponding value figures.

[20]Although, because of strengthened property rights overall, global production possibilities may also have increased. See Anderson (1977) and Wilson (1984, footnote 3).

Table 1.—U.S. edible and nonedible seafood exports and imports, in value terms, 1961-85.

Year	Value in thousands of dollars			
	Exports	Real exports[1]	Imports	Real imports[1]
1961	34,710	50,065	400,619	577,844
1962	35,728	50,599	489,807	693,680
1963	56,605	78,980	500,712	698,635
1964	64,204	88,229	564,243	775,379
1965	69,483	93,441	600,904	808,101
1966	84,813	110,491	719,702	937,600
1967	82,209	103,983	707,883	895,374
1968	67,757	82,090	822,669	996,691
1969	104,533	120,444	844,293	972,800
1970	117,484	128,468	1,037,410	1,134,401
1971	139,245	145,032	1,074,201	1,118,843
1972	157,908	157,908	1,494,411	1,494,411
1973	299,168	282,901	1,583,133	1,497,052
1974	262,132	227,252	1,710,878	1,486,686
1975	304,729	242,252	1,637,099	1,301,454
1976	384,690	290,683	2,328,186	1,759,246
1977	520,496	371,650	2,633,606	1,880,476
1978	905,534	602,004	3,085,951	2,051,556
1979	1,085,816	664,514	3,808,791	2,330,676
1980	1,014,527	568,681	3,648,452	2,045,096
1981	1,178,000	602,249	4,206,011	2,150,312
1982	1,095,285	528,103	4,523,578	2,181,088
1983	1,072,742	498,255	5,129,372	2,382,430
1984	1,027,881	460,108	5,883,393	2,633,569
1985	1,188,434	512,919	6,678,596	2,882,433

[1]Deflated by the GNP deflator, 1972=100
Source: National Marine Fisheries Service, "Fisheries of the United States, 1961-85."

Table 2.—U.S. exports and imports of agricultural commodities, in value terms, 1961-82.

Year	Value billions of dollars			
	Total exports	Total imports	Real exports[1]	Real imports[1]
1961	5.0	3.7	5.3	5.3
1962	5.0	3.9	7.1	5.5
1963	5.6	4.0	7.8	5.6
1964	6.3	4.1	8.7	5.6
1965	6.2	4.1	8.3	5.5
1966	6.9	4.5	9.0	5.9
1967	6.4	4.5	8.1	5.7
1968	6.3	5.0	7.6	6.1
1969	6.0	5.0	6.9	5.8
1970	7.3	5.8	8.0	6.3
1971	7.7	5.8	8.0	6.0
1972	9.4	6.5	9.4	6.5
1973	17.7	8.4	16.7	7.9
1974	21.9	10.2	19.0	8.9
1975	21.9	9.3	17.4	7.4
1976	23.0	11.0	17.4	8.3
1977	23.6	13.4	16.9	9.6
1978	29.4	14.8	19.6	9.8
1979	34.7	16.7	21.2	10.2
1980	41.2	17.4	23.1	9.7
1981	43.3	16.8	22.2	8.6
1982	36.6	15.3	17.6	7.4
1983	36.1	16.5	16.8	7.7
1984	37.8	19.3	16.9	8.6
1985[2]	29.1	19.5	12.6	8.4

[1]Deflated by GNP deflator, 1972=100
[2]Estimated values.
Source: USGPO (1986) and other annual volumes.

Table 3.—U.S. international transactions, merchandise exports and imports (excluding military) in millions of dollars[1].

Year	Exports	"Real" Exports[1]	Imports	"Real" Imports[1]
1961	20,108	29,003	14,537	20,968
1962	20,781	29,431	16,260	23,028
1963	22,272	31,076	17,048	23,787
1964	25,501	35,043	18,700	25,697
1965	26,461	35,585	21,510	28,927
1966	29,310	38,184	25,493	33,211
1967	30,666	38,788	26,866	33,962
1968	33,626	40,739	32,991	39,970
1969	36,414	41,956	35,807	41,257
1970	42,469	46,440	39,866	43,593
1971	43,319	45,119	45,579	47,473
1972	49,381	49,381	55,797	55,797
1973	71,410	67,527	70,499	66,666
1974	98,306	85,424	103,811	90,192
1975	107,088	85,132	98,185	78,048
1976	114,745	86,705	124,228	93,899
1977	120,816	86,266	151,907	108,428
1978	142,054	94,438	176,001	117,022
1979	184,473	112,883	212,009	129,748
1980	224,269	125,711	249,749	139,994
1981	237,085	121,209	265,063	135,513
1982	211,198	101,831	247,642	119,403
1983	201,712	93,689	268,928	124,909
1984	219,916	98,440	334,023	149,518
1985[2]	216,640	93,500	333,375	143,882

[1]Deflated by GNP deflator, 1972 = 100.
[2]Estimated values.
Source: USGPO (1986) and other annual volumes.

the world's resources were masked because most of the changes in fisheries jurisdiction occurred when overall trading relationships were being realigned.

While EJ may have led to a smaller increase in the world's wealth than suggested by the trade data, redistribution of that wealth has generated both gainers and losers. We turn next to a discussion of international seafood trade by one expected gainer: the United States.

U.S. Seafood Trade and Extended Jurisdiction

With the declaration of the Magnuson Fisheries Conservation and Management Act (MFCMA) of 1976, it would not have been unreasonable to anticipate increased domestic landings and, thus, both less reliance on seafood imports and increased export activity by the United States. In fact, what has happened? The average annual harvest by U.S. commercial fishermen during the 3 years immediately prior to the MFCMA was 5 billion pounds. By 1980-82 this figure had increased to 6.8 billion pounds, an increase of over 30 percent. The dollar value of fishery exports (measured in 1972 dollars) rose from an average of $251 million to one of $555 million, an increase of more than 120 percent over the same period[21]. On the import side, the dollar value also rose, from a 1973-75 average of $1,428 million to a 1980-82 average of $2,125 million. On a per-capita basis, this represented an increase of 38 percent. Thus, while imports increased over the period, exports increased even more significantly, lending support to the hypothesis that, at least for the United States, extended fisheries jurisdiction led to increased export activity and a substitution of domestically harvested seafoods for imports.

A closer look at the data suggests the need for caution in attributing changes in trade activity to extended jurisdiction, however. Tables 1-3 and Figures 4 and 5 show U.S. imports and exports (in value terms), respectively, of fishery products, agricultural products, and all merchandise for 1961-85. Comparison of these data reveals some remarkable similarities.

On the import side, for example, the figures in all three categories increased in approximately linear fashion during 1962-71. Exports followed a similar pattern, with the exception of a drop in agricultural exports between 1966 and 1969. In the early 1970's exports of all three classes increased dramatically—and so did imports. Following a brief decline in the mid 1970's, exports of all merchandise and of agricultural products once again increased through the end of that decade. Seafood exports also rose over the period, peaking in 1979. While annual fluctuations should not be ignored, it is interesting to note that, from the late 1960's to the late 1970's all three groups rose exponentially—or, at least, more rapidly than during the early 1960's. During the past 4 or 5 years, there has been a decline in exports for the three groups[22]. The point of this exercise is to suggest that there do not seem to be significant differences between the exports

[21]These figures include direct sales by U.S. fishermen to foreign processors but exclude deliveries by U.S. fishermen to foreign ports.

[22]There were exceptions in 1984 for the nonseafood categories and in 1985 for seafoods.

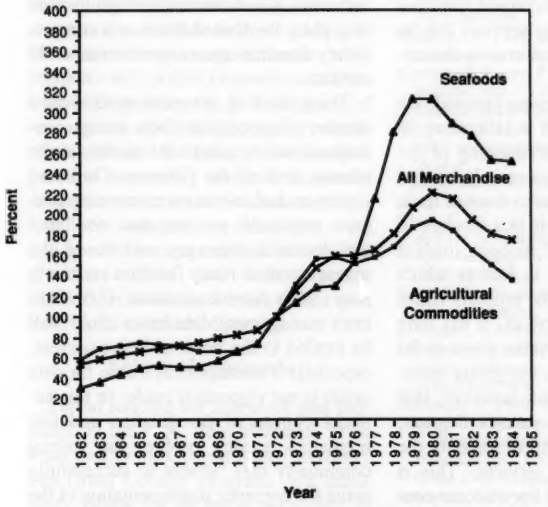

Figure 4.—U.S. exports of seafoods, agricultural commodities, and all merchandise: Percent of 1972 real values (1972 = 100), based on 3-year moving averages. Source: Tables 1, 2, and 3.

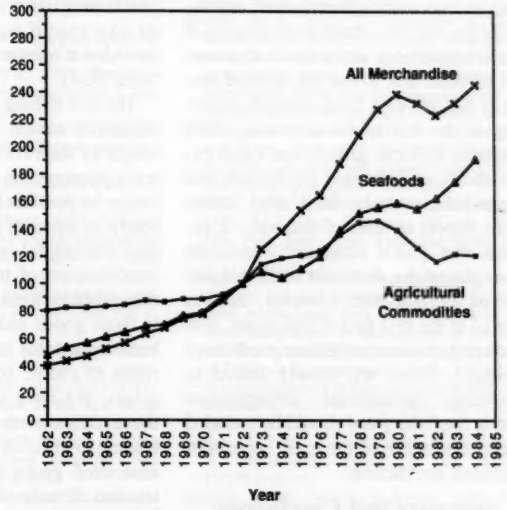

Figure 5.—U.S. imports of seafoods, agricultural commodities, and all merchandise: Percent of 1972 real values (1972 = 100), based on 3-year moving averages. Source: Tables 1, 2, and 3.

of fishery products and the overall export activity of the United States. While seafood exports have increased with the MFCMA, so, also, have exports of agricultural commodities and of all merchandise taken together. Furthermore, the recent decline in seafood exports parallels similar declines in other export sectors of the U.S. economy. It would be difficult to attribute these patterns to extended fishery jurisdiction.

What about imports? Here the situation is similar. Aside from the 1973-76 period, imports of products in all three sectors grew between 1961 and 1979. Since 1979, however, there has been a difference, with seafoods showing a drop between 1979 and 1980, and increases since then. The recovery did not begin until 1983 for agricultural imports and imports of all merchandise. With this exception, the general conclusion is similar to that reached for exports: The seafood sector looks very similar to other sectors of the U.S. economy, as measured by changes in economic activity.

Johnston and Siaway (1985) explored this issue statistically, using data for 1961-82. Their analysis suggests that, while extended fisheries jurisdiction appears to above played a role in U.S. seafood exports, patterns in both imports and exports have been importantly determined by macroeconomic factors, including exchange rates: The same macroeconomic factors that lie behind U.S. trade patterns in general. This finding is hardly surprising. It is simply a result of the interdependencies between the fisheries sector and the rest of the economy. It is also consistent with a similar finding by McCalla (1982) for U.S. agriculture.

We do not mean to suggest that events within the fisheries sector are unimportant in understanding seafood trade. On the contrary, a number of events, some of them spawned by the Magnuson Act, have played major roles in particular markets for particular species.

In the case of Pacific salmon, for example, legislation of the mid-1970's, strengthened by the Magnuson Act, enabled the United States and Canada to control interception of North American salmon by the Japanese distant-water fleets. This and favorable climatic and oceanographic conditions led to large runs of salmon being made available to the Alaska fleets. Increased availability of salmon in the United States and decreased availability in Japan resulted in increased exports by U.S. supplies to the Japanese market. In addition, the United States has experienced substantial increases in the imports of a related product: Atlantic salmon from Norway. As a farmed product, delivery is possible during those months when U.S. production is low. However, even if there had been no change in demand and supply conditions in the United States and its European markets, one could have anticipated a substitution of Norwegian for U.S. salmon, both domestically and abroad, because of the relative strength of the U.S. dollar against major European currencies, including the Norwegian Krone[23]. Other factors are also im-

[23]This situation has changed recently.

portant, but the central point here is that both microeconomic and macroeconomic variables are important determinants of market conditions in the seafood sector.

Our point here is that the seafood sector is not immune from changes occurring in the rest of the economy. With extended fisheries jurisdiction came expectations of increased production and expanded exports by the United States. With respect to sales of seafoods, it appears that global economic conditions have played the dominant role. It is important to remember, however, that, as argued in the first part of this paper, new trade patterns in intermediate goods have emerged. These are closely linked to emerging institutional arrangements within the fishery and should be included in any discussion of the trade impacts of extended jurisdiction.

Summary and Conclusions

There are theoretical and empirical bases for stating that the structure of property rights and the associated institutional arrangements are codetermined with both the level of production within a country and the types of goods traded. These rights are based upon a combination of international customary law and the level of defense and enforcement chosen. Extended fisheries jurisdiction can be viewed as leading to shifts of production possibilities schedules, but the issue is much more complex than this. Specifically, because policing the use of newly acquired resources is not costless, coastal countries may choose to participate in trade with other countries that involves bundles of services, including policing services themselves.

Thus it is not likely that the trade environment for the fishery can be completely characterized by looking at the trade statistics for fish. In fact, trade in a number of instruments which lead to the production of fish can be seen in the world today. Some of these trades may never appear in a balance of payments account. For a cash-poor country, with limited access to exploitation technology and with a relatively high cost of capital, the prospect of being able to sell some intermediate good without expensive capital expenditures on investment in defense and enforcement may be attractive indeed. A country may even choose to export fishing rights and to import fish from its own zone if policing services can be provided at relatively low cost by distant-water fleets.

The new fishing zones may provide the economic analyst with a laboratory in which to improve understanding of the trade phenomenon in general. It may no longer be possible for us to think of trade solely in terms of goods and services in any meaningful way, without explicit consideration of trade in factors which strengthen or weaken the property rights in those goods and services. It has long been argued that trade takes place in the rights to goods, not in the goods themselves. We have argued, however, that those rights come in various degrees, leading to different terms of trade for the associated goods and services. This is true for all trade; under open access conditions the property rights dimension is simply more obvious.

Much of the motivation for complete "rationalization" of the EEZ seems to stem mainly from an import/export substitution argument: The U.S. wishes to substitute imports with domestic production and to capture the export markets which ostensibly would be ours if we removed foreign fishing. There may be several drawbacks to such a policy. First, the United States competes on many primary industry markets with developing countries (e.g., grains and some meats), and it is not clear at this point that it competes well in these commodities. It is also unclear where our advantage is in the production of fish for foreign and domestic markets. Although it is clear that our natural resource base is large, production also requires appropriate types of processing technology. The cost of this technology may be relatively high. "Americanization" of the U.S. fishing zone may look different than currently envisioned.

Second, even if the necessary expenditures of investment in D&E are made, and the United States goes wholly domestic, there are many countries that cannot afford to do the same thing. They will be selling product in the form of access, or joint ventures. These types of trade arrangements, if they are numerous, encourage parties with productive inputs to search for cost efficient combinations of labor, capital, and ocean access. In these instances, Americanization of production may place the United States in a competitively disadvantageous position in world markets.

Third, the U.S. government received a number of concessions from foreign participants which aided considerably in the management of the fisheries. On-board observers and in-season monitoring generate relatively accurate data on direct and by-catch tonnages and made the management of many fisheries relatively easy. With Americanization, U.S. fisheries management data bases could well be eroded to the point of being useless, especially if management's case for data needs is not vigorously made. In this national climate of deregulation and low regulatory agency profile, the fishing community may be able to successfully resist the domestic implementation of the data collection programs previously provided by guest nations.

In summary, the United States is perfectly capable of supplying the level of D&E that will insure the complete domestication of the industry. However, whether the domestic industry will ultimately be able to compete on the world market without asking for protectionist measures in the future is uncertain. Americanization with protectionism would amout to an income transfer from consumers to another protected industry.

In the second section we demonstrated the necessity of paying attention to global macroeconomic trends when sectoral policy impacts are being assessed. This is especially true when those trends have to do with relative differences in productivity of countries, which may have an impact upon the value of currency. This and other macroeconomic phenomena have been instrumental in determining trade trends. While extended jurisdiction has not been neutral where international seafood trade is concerned, it is by no means the only driving force.

We believe that the United States will find itself increasingly in direct competition with newer and hungrier nations who will offer attractive terms of access to resource wealth. As control over the natural resource base tightens, the fishing sector will begin to show increasing similarity with the rest of primary industry in

the United States, such as agriculture, with all of the attendant drawbacks when it comes time to trade in these goods. As the sector becomes more domestic, other problems will exhibit themselves, not the least of them being the global impacts of occurrences which lie principally outside of the sector. If trade in intermediate goods is principally confined to wholly domestic processes, it is unclear at this time how competitive these processes will be after foreign resource holders and producers adjust their own property rights expectations and develop their own trade policies toward fisheries.

Acknowledgments

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Literature Cited

Alchian, A. A., and W. R. Allen. 1968. Exchange and production: Theory in use. Wadsworth Publ. Co., Inc., Belmont, Calif.

Anderson, L. G. 1977. The economics of fisheries management. Johns Hopkins Univ. Press, Baltimore.

Banks, G. 1985. Constrained markets, "surplus" commodities and international barter. Kyklos 38(2):249-267.

Batra, R. N. 1973. Studies in the pure theory of international trade. St. Martin's Press, N.Y.

Cassing, J. H., and P. G. Warr. 1985. The distributional impacts of a resource boom. J. Int. Markets 18(1985):301-309.

Caves, R. E., and R. W. Jones. 1973. World trade and payments. Little, Brown, and Co., Boston.

Chacholiades, M. 1978. International trade theory and policy. McGraw Hill, N.Y.

Clark, C. W., and G. R. Munro. 1980. Fisheries and the processing sector: Some implications for management policy. Bell J. Econ. 11(2):603-616.

FAO. 1984. Yearbook of fishery statistics, fishery commodities, 1983, vol. 54. Food Agric. Organ., U.N., Rome.

Hannesson, R. 1985. The effects of a fishermen's monopoly in the market for unprocessed fish. Mar. Resour. Econ. 2(1):75-85.

Jacobson, J. 1980. The Law of the Sea: Some unresolved problems. *In* S. Hanna, K. Im, and L. Rogers (editors), Conflict in use of ocean resources, p. 117-123. Oreg. State Univ. Sea Grant Coll. Program, Corvallis.

Johnston, R. S., and A. Siaway. 1985. Extended fisheries jurisdiction and international seafood trade. *In* Proceedings of the Second Conference of the International Institute of Fisheries Economics and Trade, Volume 2: A compendium of papers on seafood trade and markets, p. 17-29. Oreg. State Univ., Corvallis.

Lindert, P. H., and C. P. Kindleberger. 1982. International Economies, 7th edition. Richard S. Irwin, Inc., Homewood, Ill.

McCalla, A. F. 1982. Impact of macroeconomic policies upon agricultural trade and international agricultural developments. Am. J. Agric. Econ. 64(5):861-868.

Morris, M. E. 1986. The expansion of Third World navies. Macmillan, Lond. In press.

Munro, G. R. 1985. The economics of coastal state-distant water nations co-operative arrangements: Some long run considerations. *In* Proceedings of the Second Conference of International Institute of Fisheries Economics and Trade. Volume 1: Economic recovery, fisheries economics and seafood trade, p. 271-285. Oreg. State Univ., Corvallis.

NMFS. 1986. Fisheries of the United States, 1985. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Curr. Fish. Stat. 8380, 122 p.

Samples, K. C. 1985. Export marketing strategies for fish and fisheries products: Lessons from international tuna joint ventures in the southwest Pacific. *In* Proceedings of the Second Conference of the International Institute of Fisheries Economics and Trade, Volume 2: A compendium of papers on seafood trade and markets, p. 99-109. Oreg. State Univ., Corvallis.

Sarkar, A. 1985. A model of international trade in intermediate goods. J. Int. Econ. 19(1985):85-98.

Sutinen, J. M., and P. Andersen. 1985. The economics of fisheries law enforcement. Land Econ. 61(4):387-397.

Svejnar, J., and S. C. Smith. 1984. The economics of joint ventures in less developed countries. Quart. J. Econ. Feb., p. 149-167.

Tomlinson, J. W. C., and I. Vertinsky. 1975. International joint ventures in fishing and 200-mile economic zones. J. Fish. Res. Board Can. (32):2569-2579.

USGPO. 1986. Economic report of the President. U.S. Gov. Print. Off., Wash., D.C.

Interdependencies Among Fisheries Management, Fisheries Trade, and Fisheries Development: Experiences with Extended Jurisdiction. Discussion

DOUGLAS W. LIPTON

The task given to these authors of describing the interrelationships between fisheries trade, development, and management was enormous. Rather than trying to cover all the interrelationships, they have chosen to focus on two that they feel are important: 1) The endogeneity of the level of property rights and the pattern and terms of trade of a nation, and 2) the effect of exogenous factors, particularly global macroeconomic trends, on trade. The bulk of the paper is devoted to the first topic because it requires greater theoretical development and is inherently more complex than the treatment of exogenous factors. Therefore, I will dispose of my comments on the exogenous factors section first, and then address the property rights issue.

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The importance of exogenous factors to fisheries trade is demonstrated in a simple, but effective, way. Comparison of trends in fisheries imports and exports are made to the trends in other commodities. Figures 4 and 5 demonstrate the remarkable similarities in these trends, making the case for the influence of macroeconomic factors. However, these same diagrams are also striking in the dissimilarities between fisheries and the other commodities. In particular, for both imports and exports, the sharp increase of the 1970's starts a year earlier and the response is greater than the other commodities.

One of the reasons for the increase in exports, the fortuitous events in the U.S. salmon market, is discussed in the text, but an even more significant event was the increase in king crab exports from $11.9 million in 1976 to $29.0 million in

1977. This, too, was not a direct result of the MFCMA, but a short-lived boom in a fishery that collapsed in 1983. This lends further support to the theory that the MFCMA did not have a major impact on U.S. seafood trade. The policy implications of this are not discussed, but it certainly brings into question the effectiveness of active Federal promotion of U.S. exports (trade missions, fish-and-chips allocation policy) when global macroeconomic and biological events are the main drivers of the system.

This paper, however, acknowledges that underneath the fishery sector responses to exogenous forces, there are institutional changes occurring within the fishery sector that can be attributed to extended jurisdiction. The major premise of the study is that the vector of goods and services traded is not only a function of the demand for the goods and the cost of inputs, but also of the institutional arrangements, the level of expenditures to enforce these arrangements and the subsequent property rights (Fig. 1). Thus, examining trade by just looking at quantities and prices in the traditional trade models will not provide an adequate explanation of what is occurring. The remainder of this section is the authors' attempt at a generalized framework to introduce these institutional factors into the traditional trade model. I applaud this approach and believe the authors are on the right track. For the United States there has clearly been a shift in trade patterns that do not show up in the statistics. The United States is heavily involved in counter-trading which is exactly what its fish-and-chips policy is. Joint ventures emerged only when the MFCMA made them a necessity.

I have one specific comment related to the equilibrium solution portrayed in Figure 3. The solution depicted is a specific solution to the problem when the objective is maximizing joint domestic and foreign rents. The marginal cost of foreign D&E to the home country is zero, as is the cost to the foreign country of domestic D&E. For each country, it is optimal for the other to supply all the D&E. Also, each country has its own marginal benefit curve depending on the allocation of catch. It is also possible that the domestic country will extract more rent from the foreigners by negotiating for a level of foreign D&E at which marginal cost exceeds foreign marginal benefits.

I believe the authors approach could be strengthened if a stronger tie is made to fisheries management. Enforcement of an exclusive economic zone will have different effects depending on the type of management that exists. In the typical U.S. case, there are strong property rights for the United States vs. the foreign fishing nation. However, within the domestic fishery there are weak or no property rights. In this case, replacement of foreign fishing by an open access domestic fishery results in a shift in economic activity to the United States, but not necessarily any welfare gains, and thus, no returns to defense and enforcement.

My final comment relates to an aspect of fisheries trade, management, and development not discussed in the paper, the impact of protectionist import policies and export development on domestic fisheries. Many involved in making those policies are basing their decisions on the conventional wisdom that protection from imports will raise the price received by domestic producers and the quantity supplied. The problem is that the outcome is not at all clear in an open-access fishery. Prices will surely rise, but quantity supplied may fall if the fishery is in the backward bending portion of the supply curve. The policy implications of these interactions are tremendous, given the current pressures for protectionist measures at the same time that fisheries managers are trying to limit domestic effort. Development and discussion of these points would have made for a more complete discussion of the major issues involving fisheries trade, development and management.

The Horseshoe Crab, *Limulus polyphemus*, Fishery and Resource in the United States

MARK L. BOTTON and JOHN W. ROPES

Introduction

The American horseshoe crab, *Limulus polyphemus* (L.), has long been economically important despite its lack of food value to humans (Wells *et al.*, 1983). Crabs were ground into livestock feed and fertilizer between the 1870's and 1920's; the industry, centered in Delaware Bay, reported annual harvests of over 1 million crabs (Shuster and Botton, 1985). Economic considerations, public complaints about offensive odors, and possibly diminishing stocks contributed to the decline of this industry.

Commercial interest in the species was revived by the discovery that its blood coagulates in the presence of minute quantities of gram-negative bacterial endotoxin (Novitsky, 1984). This unique property has been exploited to develop a sensitive bioassay product called *Limulus* amoebocyte lysate (LAL). Biomedical applications of LAL include testing of pharmaceutical products, monitoring water purity in clinical laboratories, and screening for human diseases caused by gram-negative bacteria, including gonorrhea and spinal meningitis (Novitsky, 1984). According to industry sources[1], the demand for LAL may double by 1990.

The fishing mortality rate for horseshoe crab populations has not been estimated. Adult crabs are collected as bait for American eel, *Anguilla rostrata*; whelk, *Busycon* sp.; and other fisheries (Pearson and Weary, 1980). Crabs are also destroyed purposely by fishermen aware of their importance as predators on soft-shell clams, *Mya arenaria* (Smith et al., 1955), and surf clams, *Spisula solidissima* (Botton and Haskin, 1984). Mortalities of horseshoe crabs collected for blood extraction will be minimized in the future because the crabs must now be returned to the habitat within 72 hours after capture under a mandated conservation measure by the U.S. Food and Drug Administration (FDA). Only adult crabs are bled and relatively few succumb to the treatment. Rudloe (1983) estimated a 10 percent mortality among bled animals compared with unbled controls.

Adult horseshoe crabs are easily harvested during the spring-summer mating season. Animals spawn in the middle to upper intertidal zone of sandy estuarine beaches, with the largest populations occurring in the middle Atlantic region, particularly Delaware Bay (Shuster, 1982). They can be caught with a minimum of financial expense, since no special dredges or nets are required. At other times of the year, the crabs are subtidal, and are a common by-catch in otter trawls and clam dredges.

The value of horseshoe crabs cannot be measured solely in biomedical or economic terms. In particular, their breeding cycle in Delaware Bay coincides with the Arctic-bound migration of at least 20 species of shorebirds (Wander and Dunne, 1981; Botton, 1984). Delaware Bay is a critical "staging area" for many of these birds (Myers, 1983; Morrison, 1984; Dunne et al. 1982), and horseshoe crab eggs are probably their most important food item (Wander and Dunne, 1981; Botton, 1984).

As a species, horseshoe crabs have persisted for more than 200 million years;

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[1]J. Finn, Marine Biologicals Inc., Personal commun. Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

ABSTRACT—The American horseshoe crab, Limulus polyphemus, *is a focus for increasing economic and scientific importance because its blood has important biomedical applications and because the crab is used as bait in several fisheries. In addition, horseshoe crab eggs may be critical as a source of food for migratory shorebird populations of the Delaware Bay region, and adult crabs are predators of valuable clam resources. Fishing-related mortality in the United States is estimated minimally at 350,000 crabs per year, mostly in the middle Atlantic and southern New England states. Bait operations apparently kill (10-20 times the number of animals killed for bleeding to obtain the valuable* Limulus *amoebocyte lysate (LAL). Based on National Marine Fisheries Service groundfish trawl surveys, the population of horseshoe crabs on the middle Atlantic continental shelf has remained relatively constant since 1975 at 2.3-4.1 million individuals. Exploitation may not be trivial, particularly if local populations are targeted during the spawning period; we suggest several foci for further investigations on this species. There is no evidence that current levels of harvesting are depleting the resource. It is important, however, to continue monitoring activity, particularly if levels of exploitation increase.*

in spite of this, it is reasonable to ask whether the species would be resilient to intensified exploitation (Bang, 1979). This review considers the importance of commercial exploitation of horseshoe crabs based on their abundance, distribution, and natural history. We discuss possible effects of habitat degradation on horseshoe crabs and define critical gaps in the knowledge of the population ecology of horseshoe crabs requisite to conserve this valuable species.

Methods

Published National Marine Fisheries Service (NMFS) statistical resumes from 1964 to 1977, and unpublished statistical summaries at the Woods Hole Laboratory of the NMFS Northeast Fisheries Center, through 1984, were used to document the estimated catch and value of horseshoe crabs in the United States, exclusive of the LAL industry. Data reported as weight landed were converted to approximate number of crabs by assuming an average body weight of 1.8 kg (4 pounds) (Ropes et al.[2]). Fisheries statistics probably underestimate the catch, because most sales of crabs for bait are arranged between private individuals, rather than through centralized dealers (R. Schultz, personal commun.). Therefore, we used fisheries statistics as conservative estimates, and supplemented these data with the results of mail and telephone surveys of individuals with first-hand knowledge of horseshoe crab fishing within their local areas.

Questionnaires were mailed to 96 persons or companies 1) active in the bait or LAL industries, 2) affiliated with Federal or State fisheries agencies, or 3) active in scientific research with horseshoe crabs. Respondents were asked about 1) the approximate number of crabs caught in their local areas, 2) the season(s) in which they were caught, 3) the type of gear used, 4) the use(s) to which the animals were put, and 5) whether these catches were, to their knowledge, included in the NMFS fisheries statistics (to avoid possible duplication of numbers).

To estimate horseshoe crab abundance, we analyzed data from NMFS groundfish surveys which sampled the continental shelf from Cape Fear, N.C., north to the Gulf of Maine and Georges Bank (Botton and Ropes, In press; Ropes et al.[2]). Stations were selected following a stratified random design (Grosslein, 1969) which delineates strata based on depth and area. Stratified mean numbers per tow of horseshoe crabs were converted into an estimate of standing stock by using the "area swept" by a standard survey trawl in relation to catch (in numbers) as an estimate of minimum absolute density. Total populations were estimated by expanding the average stratified mean catch per tow by the ratio of total area surveyed to the area sampled by an average tow. Fall (September-early December) and Spring (March-May) surveys provided the most thorough coverage of the middle Atlantic region, where crabs are most abundant; population estimates from 1975 to 1983 are included in this report. Most of the crabs retained by the trawl were adult size (Botton and Ropes, unpubl. data). Estimates must be considered as minimum population estimates because the trawls are equipped with rollers and do not sample crabs with 100 percent efficiency; furthermore, horseshoe crabs occurring shoreward of the NMFS strata would not be included. Gear specifications and further analyses of the groundfish trawl data are available in Ropes et al.[2] and Botton and Ropes (In press). Estimates of horseshoe crab populations in several estuaries were obtained from published sources.

Results

Of 96 questionnaires mailed, we received 53 responses (55 percent), of which 46 (48 percent) provided detailed answers to most or all questions. Of these 46 respondents, 10 were affiliated with private industry, 10 with state or local fisheries programs, 9 with the Federal government, and 17 with marine research facilities. Seventy-six percent of the respondents were from the middle Atlantic and southern New England regions, where commercial exploitation of the species is highest. Seven NMFS Fisheries Reporting Specialists (persons responsible for gathering commercial fisheries statistics) responded to our survey in writing or orally.

According to many of our sources, and the monthly fisheries statistics from the middle Atlantic states, most horseshoe crabs are caught during spring and summer (Table 1), the seasons during which crabs are reproductively active. Many are caught by hand from the breeding beaches. Egg-bearing females are regarded as superior bait for eels and whelks, and many fishermen will not use males in their traps unless the supply of females is depleted.

Table 1.—Estimated average horseshoe crab catch (animals/year) in the United States, exclusive of animals used in LAL operations. Capture methods and uses are presented in order of importance.

State	Estimated catch	Time of Year[1]	Methods of capture	Major uses	Data sources[2]
ME	Negligible				FS, PC
NH	1,200	2,3	Hand	Research	PC
MA	7,500	2,3,4	Hand, dredge, trawl	Whelk and eel bait, research	PC
RI	125,000-150,000	2,3,4	Hand, dredge, trawl	Whelk and eel bait	PC
CT	0-4,000	2,3	Hand, dredge	Whelk and eel bait	PC
NY	<1,000	2,3,4	Dredge, trawl, pound net, hand	Whelk and eel bait	PC
NJ	10,000-15,000	2,3,4	Hand, dredge, trawl	Whelk and eel bait	PC
DE	100,000-500,000	2,3	Hand, dredge, trawl	Eel bait	FS, PC
MD	43,000-70,000	2,3	Dredge, trawl, hand	Eel and other bait	FS, PC
VA	60,000	All	Dredge, trawl, pound net	Eel bait, research	FS, PC
NC	400-8,000	All	Trawl	Eel bait	FS, PC
SC	Negligible				FS
GA	Unknown				PC
FL	1,000	All	Hand, trawl	Research	PC
Total	348,000-817,000				

[1] 1 = winter, 2 = spring, 3 = summer, 4 = fall.
[2] FS = NMFS statistics, PC = personal communication.

[2] Ropes, J. W., C. N. Shuster, Jr., L. O'Brien, and R. Mayo. 1982. Data on the occurrence of horseshoe crabs, *Limulus polyphemus* (L.), in NMFS-NEFC survey samples. Woods Hole Lab. Ref. Doc. 82-23, 40 p.

Commercial Bait Fishery

In New England, there is little or no harvesting of horseshoe crabs in Maine, New Hampshire, or Connecticut. In recent NMFS statistics, Connecticut has reported no more than 4,000 crabs in any recent year; none have been reported from Maine or New Hampshire (Table 1). Born (1977) reported, however, that "adults by the truckload" were removed for bait from the Damariscotta River, Maine in 1976.

Elsewhere in New England, horseshoe crabs are collected from Cape Cod Bay, Pleasant Bay, Nantucket Sound, Nantucket Harbor, and Buzzard's Bay, Mass., and most significantly, Narragansett Bay, R.I. NMFS statistics have recorded very few crabs from both states between 1964 and 1984, although respondents to the questionnaire estimated annual catches of at least several thousand crabs in Massachusetts and over 100,000 in Rhode Island (Table 1). Recently, the demand for eels has been extremely variable; the demand for eel bait has fluctuated accordingly (B. Kelly, W. Sargent, personal commun.).

The largest horseshoe crab fishery is located in the middle Atlantic states, although we experienced some difficulty in estimating numbers. NMFS statistics from New York and New Jersey have recorded no more than a few hundred crabs per year since 1974. Three respondents from New York indicated the catch is probably larger than this, although definitive estimates could not be made. Six respondents from New Jersey estimated catches of about 10,000-15,000 crabs per year from all areas of the state, including Raritan Bay, Sandy Hook Bay and adjacent rivers, Delaware Bay, and offshore, principally from Atlantic City to Cape May.

As recently as 1979, up to 500,000 crabs were harvested annually from Delaware, primarily for processing into chicken feed (W. Brey, personal commun.). The plant doing this is no longer operational, but harvesting for eel bait continues. Both the Chesapeake Bay and the ocean provide Maryland and Virginia fishermen with a substantial horseshoe crab resource. Recent NMFS statistics documented catches of 43,000-70,000 crabs from Maryland and some 60,000 from Virginia (Table 1).

Several thousand horseshoe crabs are caught in North Carolina for eel bait; south of there, uses are limited to lysate extraction and scientific research (Table 1).

Commercial LAL Fishery

LAL manufacturers must return bled crabs to the habitat; hence, their crabs are not included in NMFS statistics. At present, eight companies have FDA licenses to manufacture LAL (Novitsky, 1984). While the exact number of animals bled by each firm is not available or is considered confidential, our questionnaire responses suggest an average of about 20,000 per year. Thus, the total number of crabs bled may be about 160,000.

Commercial Fishing Summary

The annual commercial catch of horseshoe crabs for bait is estimated at between 348,000 and 817,000 animals per year (Table 1). This figure omits possible contributions from states (New York, South Carolina, and Georgia) where either estimates were unavailable or too variable to utilize. The bleeding of crabs to obtain lysate imposes a 10 percent mortality (Rudloe, 1983); if about 160,000 crabs are bled annually, then bleeding operations for lysate production may kill about 16,000 crabs per year. Several respondents emphasized that destruction of crabs by fishermen in some locations may be as significant a source of mortality as either lysate bleeding or bait fishing.

Population Estimates

Based on NMFS surveys of the middle Atlantic continental shelf between 1975 and 1983, there is a minimum population of some 2.3-4.1 million horseshoe crabs (Table 2). Although several surveys, notably Spring 1976 and Spring 1977, had considerably larger totals, there is no consistent trend in population size over the 9-year interval. About 98 percent of the population is located between Cape Hatteras (lat. 35°N) and New Jersey (lat. 41°N), mostly at depths shallower than 20 m (Botton and Ropes, In press).

Horseshoe crab populations from Plum Island Sound, Massachusetts, Cape Cod Bay, Delaware Bay, Cold Spring Harbor, New York, and a portion of the Gulf of Mexico have been estimated previously (Table 3). A total estimate of the horseshoe crab population inshore of the NMFS surveys is difficult to obtain because of the discrepancies in methods and the time interval between the survey dates. Moreover, there have been no quantitative studies in several key locations, such as Chesapeake Bay, where horseshoe crabs are abundant (Shuster[3]).

Of the estuaries studied, Delaware Bay has the largest population. Shuster and Botton (1985) estimated some 250,000 animals spawning on one spring tide in June 1977, with a total adult population (over the entire spawning season) probably several times this number. Thus, the total adult population size over all estuaries is several million individuals. Since crabs migrate between the estuaries and shelf (Botton and Haskin, 1984), one should not simply add the estuarine and shelf estimates to estimate the total popu-

Table 2.—Estimated horseshoe crab population size (in millions of individuals) on the middle Atlantic continental shelf, Virginia to New Jersey, by year and season, based on National Marine Fisheries Service groundfish surveys. "Inshore" refers to continental shelf strata from the shoalward limit (8 m) to 27 m; "offshore" strata are deeper than 27 m.

		Horseshoe crab population		
Year	Season	Inshore	Offshore	Total
1975	Spring	n/a	0.000	n/a
	Fall	1.265	0.065	1.330
1976	Spring	7.376	5.100	12.476
	Fall	1.948	0.565	2.512
1977	Spring	4.707	3.346	8.053
	Fall	2.530	0.906	3.436
1978	Spring	1.688	0.502	2.190
	Fall	0.991	0.000	0.991
1979	Spring	2.832	0.771	3.603
	Fall	2.818	0.622	3.440
1980	Spring	1.126	1.465	2.591
	Fall	1.041	0.613	1.654
1981	Spring	5.009	1.013	6.022
	Fall	1.820	0.615	2.435
1982	Spring	1.214	0.725	1.939
	Fall	2.465	1.094	3.559
1983	Spring	0.869	0.081	0.950
	Fall	1.987	0.288	2.275
Mean Spring		3.103	1.034	4.137
Mean Fall		1.874	0.418	2.292

[3]Shuster, C. N., Jr. 1985. Introductory remarks on the distribution and abundance of the American horseshoe crab, *Limulus polyphemus*, spawning in the Chesapeake Bay area. Pap. pres. at Natl. Mar. Educ. Conf. 30 July-3 August 1985, Williamsburg, Va.

Table 3.—Previous horseshoe crab population estimates. Methods employed were (1) mark-recapture; (2) direct counts of animals along breeding beaches.

Location	Survey date	Survey method	Estimated population	Authority
Cape Cod Bay	1949-1950	1	50,000-100,000	Shuster, 1950
Plum Island Sound, Mass.	1952-1955	1	151,000-1,000,000	Baptist et al., 1957
Cold Spring Harbor, N.Y.	1957	1	10,000-15,000	Sokoloff, 1978
Marshes Sand Beach, Fla.	1976-1977	1	33,000	Rudloe, 1980
Delaware Bay	June 1977	2	274,000[1]	Shuster and Botton, 1985

[1]Estimate of the spawning population on one of several peaks during the mating season; total population in the bay was not estimated.

lation, as that would create the potential for double-counting an unknown portion of the population.

Discussion

Do present levels of exploitation compromise the survival of a horseshoe crab population large enough to sustain commercial enterprises? In recent years some 348,000 to 817,000 adult crabs per year have been used for bait and feed, about 16,000 killed during LAL operations, and an unknown quantity destroyed by clammers. Relative to an estimated standing stock of some 2-4 million animals on the continental shelf, and an estuarine population of the same order of magnitude, exploitation is not a small factor in the crab's demographic makeup.

The LAL industry, whose handling of crabs is regulated by the FDA, contributes far less to mortality than does the bait industry. Caution must be advised, however, in reviewing these data. The estimate of bleeding mortality uncritically assumes Rudloe's (1983) finding that crabs bled during the spring in Florida had a 10 percent higher mortality than controls. It may be prudent to estimate bleeding mortality under a wider range of environmental conditions. We must also emphasize the difficulties we experienced in estimating the size of the bait fishery, because of the decentralized nature of these operations.

Habitat modification is considered to be a principal factor in the declining population of the ecologically similar Japanese horseshoe crab, *Tachypleus tridentatus* (Nishii, 1975). The Association for the Conservation of Horseshoe Crabs was established in 1978 to protect this species (Sekiguchi and Nakamura, 1979). The role of habitat degradation in the population dynamics of *Limulus polyphemus* may also be important. For example, beach stabilization practices in several communities along the New Jersey shore of Delaware Bay include the deposition of "clean fill" (bricks, cinderblocks, and coarse gravel) in the intertidal zone. This practice diminishes the suitability of the habitat for egg laying.

Furthermore, several estuaries with large horseshoe crab populations have been impacted by pollutants. In bioassays, horseshoe crab eggs and juveniles exhibited signs of sublethal stress (delayed moulting and elevated oxygen consumption) after exposure to oil or chlorinated hydrocarbons (Neff and Giam, 1977; Laughlin and Neff, 1977; Strobel and Brenowitz, 1981). Though, on balance, horseshoe crabs are more tolerant of degraded water quality than many other marine organisms (Laughlin and Neff, 1977), the long-term synergistic effects of pollutants should be investigated.

Life history statistics for horseshoe crabs are incompletely known, yet vital to an understanding of recruitment and population dynamics. For example, the estimated growth rate, 9-11 years to attain adult size, is based on evidence from a single aquarium specimen (Shuster, 1950). Knowledge of longevity (14-19 years) is based on the recoveries of seven tagged animals 4-6 years after release (Ropes, 1961). Estimates of fecundity are limited to seven females from Florida (Cohen and Brockmann, 1983) and 14 females from Delaware Bay (Shuster and Botton, 1985).

There is virtually no quantitative data on natural mortality in horseshoe crabs, although there are many potential predators of eggs and larvae, most notably shorebirds and fish (reviewed by Shuster, 1982; Wells et al., 1983). Extensive gill pathology caused by triclad flatworms (Groff and Leibovitz, 1982) and cyanobacteria (Leibovitz, In press) has been noted in both wild and captive crabs, but the possible significance of these diseases at the population level is unknown. Even if our estimates of population size and fishing-related mortality were completely reliable, predicting the possible outcome of harvesting cannot be made without fundamental life history data.

In our opinion, based on the present fishery and population size, there is no immediate threat to the survival of *Limulus polyphemus*. There is no evidence from the NMFS surveys of the middle Atlantic continental shelf that populations are declining under present harvest levels. This does not imply that populations cannot potentially be overfished. As early as the late 1880's, decreasing CPUE was recorded by the Delaware Bay crab fishery (Smith, 1889). The size of the Delaware Bay spawning population during the early 1950's was about one order of magnitude smaller than in the late 1970's (Shuster and Botton, 1985), suggesting that recovery from the intensive fertilizer industry required several decades. It is unlikely that present commercial uses of horseshoe crabs will ever remove as many individuals as did the fertilizer industry, even allowing for a considerable expansion of LAL uses, but this does not remove the potential for detrimental effects of intensive fishing on local populations. In particular, the NMFS trawl data strongly suggests that populations in New England are at least partially isolated from the large middle Atlantic population (Botton and Ropes, In press). It must also be recognized that critical spawning areas have been, or are likely to be, adversely impacted by coastal development and pollution. Moreover, the present bait fishery is selective for egg-bearing females, which could threaten both horseshoe crab repro-

ductive success and the shorebirds (in Delaware Bay) dependent on these eggs. Finally, the relationships and importance of the crabs to the ecosystem are poorly understood but are important. Close scrutiny of the horseshoe crab resource will be necessary in the future so as to provide for appropriate management.

Acknowledgments

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Literature Cited

Bang, F. B. 1979. Finale. *In* E. Cohen (editor), Biomedical applications of the horseshoe crab (Limulidae), p. 677-680. Alan R. Liss, N.Y.

Baptist, J. P., O. R. Smith, and J. W. Ropes. 1957. Migrations of the horseshoe crab, *Limulus polyphemus*, in Plum Island Sound, Massachusetts. U.S. Dep. Int., Fish. Wildl. Serv. Spec. Sci. Rep.-Fish. 220, 15 p.

Born, J. W. 1977. Significant breeding sites of the horseshoe crab (*Limulus polyphemus*) in Maine and their relevance to the critical areas program of the state planning office. Plan. Rep. 28, State Planning Office, Augusta, Me., 1-44.

Botton, M. L. 1984. Effects of laughing gull and shorebird predation on the intertidal fauna at Cape May, New Jersey. Est. Coastal Shelf Sci. 18:209-20.

_____ and H. H. Haskin. 1984. Distribution and feeding of the horseshoe crab, *Limulus polyphemus*, on the continental shelf off New Jersey. Fish. Bull. (U.S.) 82:383-89.

_____ and J. W. Ropes. In press. Populations of horseshoe crabs on the northwestern Atlantic continental shelf. Fish. Bull. (U.S.) 85(4).

Cohen, J. A., and H. J. Brockmann. 1983. Breeding activity and mate selection in the horseshoe crab *Limulus polyphemus*. Bull. Mar. Sci. 33:274-81.

Dunne, P., D. Sibley, C. Sutton, and W. Wander. 1982. Aerial surveys in Delaware Bay: Confirming an enormous spring staging area for shorebirds. Wader Study Group Bull. 35:32-33.

Groff, J. M., and L. Leibovitz. 1982. A gill disease of *Limulus polyphemus* associated with triclad turbellarid worm infection. Biol. Bull. 163:392.

Grosslein, M. D. 1969. Groundfish survey program of BCF Woods Hole. Commer. Fish. Rev. 38(8-9):22-30.

Laughlin, R. B. and J. M. Neff. 1977. Interactive effects of temperature, salinity shock and chronic exposure to No. 2 fuel oil on survival, development rate and respiration of the horseshoe crab, *Limulus polyphemus*. *In* D. A. Wolff (editor), Fate and effects of petroleum hydrocarbons in marine organisms and ecosystems, p. 182-94. Pergammon, Oxford.

Leibovitz, L. In press. Cyanobacterial diseases of the horseshoe crab (*Limulus polyphemus*). Biol. Bull.

Morrision, R. I. G. 1984. Migration systems of some new world shorebirds. *In* J. Burger and B. Olla (editors), Shorebirds: Migration and foraging behavior, p. 125-202. Plenum, N.Y.

Myers, J. P. 1983. Conservation of migrating shorebirds: Staging areas, geographic bottlenecks, and regional movements. Am. Birds 37:23-24.

Neff, J. M., and C. S. Giam. 1977. Effects of Arochlor 1016 and Halowax 1099 on juvenile horseshoe crabs *Limulus polyphemus*. *In* F. J. Vernberg, A. Calabrese, F. P. Thurberg, and W. B. Vernberg (editors), Physiological responses of marine biota to pollutants, p. 21-35. Acad. Press, N.Y.

Nishii, H. 1975. A monograph on the horseshoe crab. (In Jpn.) Publ. by Dr. Nishii, Educ. Committee, Kasaoka City, Okayama Prefecture 714, Jpn.

Novitsky, T. J. 1984. Discovery to commercialization: The blood of the horseshoe crab. Oceanus 27:13-18.

Pearson, F. C., and M. Weary. 1980. The *Limulus* amoebocyte lysate test for endotoxin. BioScience 30:461-64.

Ropes, J. W. 1961. Longevity of the horseshoe crab, *Limulus polyphemus* L. Trans. Am. Fish. Soc. 90:79-80.

Rudloe, A. 1980. The breeding behavior and patterns of movement of horseshoe crabs, *Limulus polyphemus*, in the vicinity of breeding beaches in Apalachee Bay, Florida. Estuaries 3:177-83.

_____. 1983. The effect of heavy bleeding on mortality of the horseshoe crab, *Limulus polyphemus*, in the natural environment. J. Invert. Pathol. 42:167-76.

Sekiguchi, K., and K. Nakamura. 1979. Ecology of the extant horseshoe crabs. *In* E. Cohen (editor), Biomedical applications of the horseshoe crab (Limulidae), p. 37-45. Alan R. Liss, N.Y.

Shuster, C. N., Jr. 1950. Observations on the natural history of the American horseshoe crab, *Limulus polyphemus*. Woods Hole Oceanogr. Inst. Contrib. 564:18-23.

_____. 1982. A pictorial review of the natural history and ecology of the horseshoe crab *Limulus polyphemus*, with reference to other Limulidae. *In* J. Bonaventura, C. Bonaventura, and S. Tesh (editors), Physiology and biology of horseshoe crabs, p. 1-52. Alan R. Liss, N.Y.

_____ and M. L. Botton. 1985. A contribution to the population biology of horseshoe crabs, *Limulus polyphemus*, in Delaware Bay. Estuaries 8:363-382.

Smith, H. M. 1889. Notes on the king-crab fishery of Delaware Bay. Bull. U.S. Fish. Comm. 9:363-70.

Smith, O. R., J. P. Baptist, and E. Chin. 1955. Experimental farming of the soft-shell clam, *Mya arenaria*, in Massachusetts, 1949-1953. Commer. Fish. Rev. 17(6):1-16.

Sokoloff, A. 1978. Observations on populations of the horseshoe crab *Limulus*(=*Xiphosura*) *polyphemus*. Res. Popul. Ecol. 19:222-36.

Strobel, C. J., and A. H. Brenowitz. 1981. Effects of Bunker C oil on juvenile horseshoe crabs (*Limulus polyphemus*). Estuaries 4:157-59.

Wander, W., and P. Dunne. 1981. Species and numbers of shorebirds on the Delaware bayshore of New Jersey, spring 1981. N.J. Audubon Soc. Occas. Pap. 140, Rec. N.J Birds 7:59-64.

Wells, S. M., R. M. Pyle, and N. M. Collins. 1983. The invertebrate red data book. Int. Union Conserv. Nat., Gland (Switzerland).

The Decline of the Sea Urchin, *Tripneustes ventricosus*, Fishery of Barbados: A Survey of Fishermen and Consumers

ROBERT E. SCHEIBLING and PHILIP V. MLADENOV

ABSTRACT—For over a century, Barbadians have fished the sea urchin, Tripneustes ventricosus, *for its roe which they consider a traditional delicacy. However, the abundance of these sea urchins has declined drastically in recent years resulting in the collapse of this fishery. Interviews with sea urchin fishermen and consumers document this decline and its socioeconomic impact.*

The depopulation of T. ventricosus *occurred along the south and southeast coasts of Barbados in the late 1970's and along the east coast in the early 1980's. Prior to this decline, sea urchins were intensively harvested: Average catches exceeded 1,000 sea urchins per person per day during the height of the fishing season, providing an average income of nearly $400 Bds (or US $200) per person per week. At present, sea urchins are rare to absent on traditional fishing grounds, and although their market value has increased substantially ($25-45 Bds/liter in 1985), there has been a major loss of employment and income from this fishery.*

Overfishing appears to be a major cause of the decline of T. ventricosus. *A government-imposed closed season during the peak breeding period of these sea urchins (between May and August) is not enforced and generally unheeded. Pollution may have contributed to the decline through the deterioration of natural habitats, particularly the seaweed and seagrass beds upon which these sea urchins depend for food and shelter.*

Recovery of populations of T. ventricosus *is contingent upon recruitment via planktonic larvae; however, little is known about the mechanisms of recruitment and the ecology of the early life history stages. Artificial enhancement of recruitment, by seeding natural habitats with laboratory cultured juveniles, is a potential means of rehabilitating the sea urchin fishery.*

Introduction

Sea urchins are harvested for their gonads, which are a highly prized delicacy in parts of Asia, the Mediterranean, and the Caribbean. Worldwide, the sea urchin fishery is the most important of all of the echinoderm fisheries, with reported landings of 47,560 metric tons (t) (live weight) in 1982 (Sloan, 1985). In addition, artisanal sea urchin fisheries along the coasts of many tropical countries go largely unrecorded. These fisheries make important contributions to local economies, and some may have the potential to be expanded to meet certain export markets. At present, Japan is the greatest consumer of sea urchin roe, importing it from at least 13 countries (Sloan, 1985).

In Barbados, West Indies, a local but economically important fishery for the sea urchin *Tripneustes ventricosus* has existed for more than a century. Barbadians consider the gonads of both sexes a delicacy and large numbers of these "sea eggs" have been fished each year and sold as food. Since 1879, the Barbados Government has imposed a closed season for the fishery from May to August, the peak of the breeding season (Lewis, 1958), in an effort to conserve it (Bair, 1962). However, the abundance of these sea urchins in Barbados has declined dramatically over the past decade, and the fishery has virtually collapsed.

In this study we document the recent decline of the Barbados sea urchin fishery and its socioeconomic impact by interviewing both fishermen and consumers. Since landings are not recorded and quantitative records of sea urchin abundance in Barbados do not exist, this is the only means of obtaining such information. Moreover, these interviews provide a basis for assessing the cause and consequences of the decline, and the potential for rehabilitation of the fishery.

Methods

Fishermen Interviews

We interviewed 40 sea urchin fishermen using a prepared questionnaire (copies available from the first author). The questionnaire was divided into three parts: 1) Personal information and fishing and marketing practices, 2) questions pertaining to the decline in the fishery, and 3) questions pertaining to the cause of the decline and the potential for rehabilitation. The interviewees ranged in age from 21 to 77 years ($\bar{X}$ = 43 years). The majority were veteran fishermen—37 (52 percent) had fished sea urchins for ≥10 years, 25 (63 pecent) had fished >20 years; only 3 (6 percent) had fished <5 years. The interviews were conducted at major fishing centers (Bridgetown, Oistins), as well as in smaller villages (Silver Sands, Long Bay, Skeete's Bay, Conset Bay) (Fig. 1). We enlisted the assistance of one fisherman, Tim Jones of Long Bay, who acted as our liaison in soliciting interviewees. Before an interview, fishermen were told only that we were researchers from Canadian

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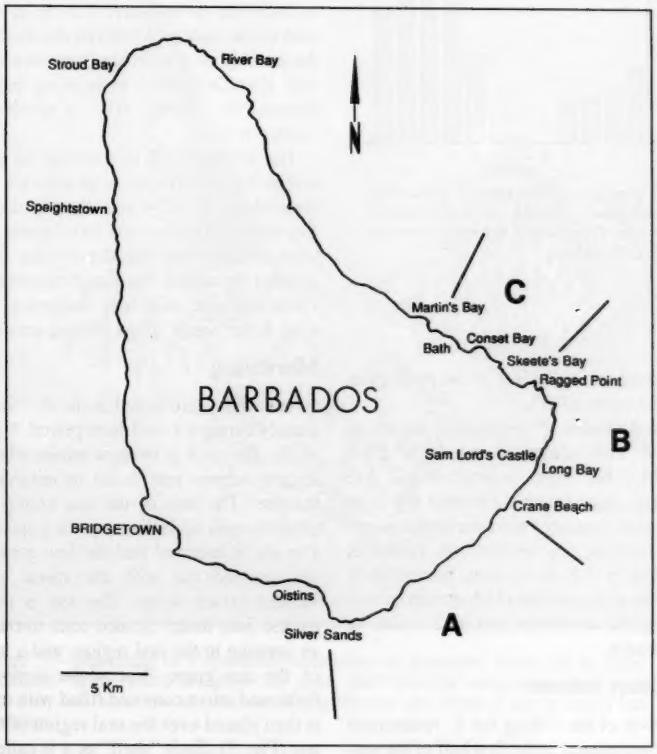
Figure 1.—Places and subareas (A, B, C) of sea urchin fishing grounds referred to in the text.



universities, unaligned with the Barbados Government, and that we wished to acquire information about the sea urchin fishery that may aid in attaining research assistance.

Consumer Interviews

Sixty Barbadian consumers were interviewed by anthropology students from Union College, N.Y., using a prepared questionnaire (copies available from the first author). The questionnaire was aimed at examining consumer preference for sea urchins and consumption habits. The respondents, representing various socioeconomic groups and occupational categories, were from the four northern parishes: St. Lucy (26), St. Peter (18), St. Andrew (9), St. James (7).

Results

Fishing Methods

Fishermen collect *Tripneustes ventricosus* by skin diving with mask, snorkel, and fins. They swim out from shore, singly or in pairs, with a floating log ("pole") from which they suspend large net bags or sacks. Sea urchins, 7-10 cm in diameter, are scraped off the rocky bottom with a small iron rod and collected in the bags which, when full, are floated back to shore on the pole. Alternatively, sea urchins may be collected in floating wooden boxes or rafts.

Fishermen may also work in teams from a boat, either a small rowboat ("Moses") or a larger (~20-foot) diesel-powered fishing boat ("day boat"). The number of fishermen per boat ranges from 2 to 6 with an average of 4 (N=20 respondents[1]). Sixty-five percent of the fishermen interviewed used both the pole-and-bag method and boats to fish for sea urchins; 25 percent used the pole-and-bag method exclusively.

In general, fishing methods have changed very little. The face mask and fins were introduced about 15-20 years ago. Although scuba is now available (and used by some spear fishermen) it is not used in the collection of sea urchins. The increasing scarcity of sea urchins has resulted in a greater dependence on boats for fishing remote populations in areas of heavy wave action. In the past many sea urchins were collected in shallow nearshore areas by wading with net bags or rafts.

[1]Where not all interviewees provided answers to a question, the number of respondents (N) is given.

Fishing Grounds

The current *Tripneustes ventricosus* fishing grounds range from Silver Sands on the south coast to Bath on the east coast (Fig. 1). This area is partitioned into three subareas for the purpose of this study: Area A, Silver Sands to Crane Beach; Area B, Crane Beach to Ragged Point; Area C, Ragged Point to Bath.

Ninety-five percent of the fishermen interviewed fished in Area B and/or Area C. Three respondents indicated that, in recent years, they had ventured as far as River Bay on the north coast to fish sea urchins. Sea urchins also were fished ex-

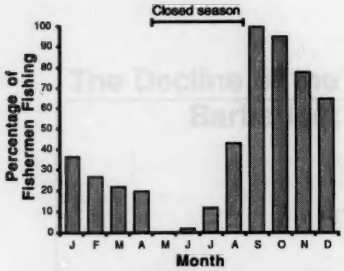


Figure 2.—Percentage of sea urchin fishermen fishing in each month when *Tripneustes ventricosus* were last abundant.

tensively at Stroud Bay on the north coast in the early 1980's.[2]

In Barbados, *T. ventricosus* occurs on patch reefs composed mainly of coral rubble, but often with scattered live corals, algae (mainly *Dictyota* spp.), or sea grass (mainly *Thalassia testudinum*). At present, sea urchins are fished at depths of 5-8 m in areas immediately within or beyond the offshore barrier reef along the southeast and east coasts of Barbados.

Fishing Season

Most of the fishing for *T. ventricosus* is concentrated in the first half of the season between September and December (Fig. 2). Sixty-five percent of fishermen interviewed admitted that they fished in the closed season, mainly in July and August. This may be a conservative estimate since some respondents may have been reluctant to admit to illegal fishing. All respondents claimed that fishing in July and August (known locally as "stealing season") is a common practice among sea urchin fishermen.

September and October represent the height of the sea urchin fishing season when virtually all of the fishermen are active. Eighty-seven percent of respondents (N=30) claimed that sea urchins were most abundant at or before the start of the season in September. Therefore the decline in the number of fishermen fishing in November and December may reflect a decrease in the abundance of sea urchins due to intensive fishing at the start of the season. A marked decrease in the number of sea urchin fishermen occurs after December, when many begin fishing for flying fish, *Cypselurus cyanopterus*.

The average (±S.D.) number of sea urchin fishing days per week reported by respondents (N=24) was 5 (±1) days. Since this did not include 14 respondents who said that they fished every day that weather permitted, this may be a conservative estimate of fishing frequency, at least at the height of the fishing season.

Marketing

Sea urchins are fished in the morning, usually during a 3- to 4-hour period. Normally, the catch is brought ashore where several helpers may assist in removing the roe. The test of the sea urchin is cracked open by hitting it with a spoon. The gut is removed and the five gonads are scooped out with the spoon and washed in sea water. The roe is then packed into intact cleaned tests through an opening in the oral region, and a leaf of the sea grape, *Coccoloba uvifera*, fashioned into a cone and filled with roe, is then placed over the oral region of the test (Fig. 3). Each "shell" as it is called, contains the roe of about 15 sea urchins[3], although the number of sea urchins needed to fill a shell may vary according to their size and reproductive condition. The unused tests are discarded in the sea or buried in large pits dug in the beach sand.

In recent years, many fishermen have elected to forego the traditional method of preparing shells, and they now package the roe in 1 or 2 liter plastic ice cream containers. One liter is equal to about 10 shells.[3]

When boats are used, the roe may be removed at sea by "crackers" who continually process the catch as it is brought aboard. The cleaned tests and guts may be discarded on the fishing grounds, although a number of fishermen that we interviewed denounced this practice, claiming that it caused the sea urchins to migrate away from the area. There may be some truth to this contention, since other species of sea urchins have been shown to be repelled by the scent of wounded conspecifics in laboratory (Tegner and Levin, 1983; Mann et al., 1984) and field (Snyder and Snyder, 1970; Vadas et al., 1986) studies.

The catch is sold fresh on the beach directly to local consumers or to vendors ("hawkers") who market the roe in the streets. Twenty percent of the fishermen we interviewed sold to hawkers. Occasionally, sea urchin roe also is sold to restaurants. The current price of the roe, quoted by the fishermen, ranged from $3-6 Bds per shell (average: $4.77 Bds; N=22 respondents) or $25-45 Bds per litre container (average: $37.30 Bds; N=14).[4] The price of roe has increased markedly in recent years. Fishermen recalled that a shell generally sold for $1-2 Bds in the early 1980's.

Fishery Decline

In recent years there has been a catastrophic decline in *ventricosus* stocks in Barbados, and at present (1986) the fishery has effectively collapsed. According to fishermen, this decline occurred initially along the south (Area A) and southeast (Area B) coasts between the middle 1970's and early 1980's, and extended to the east coast (Area C) in the early 1980's (Table 1). In general, fishermen noted that the decline of sea urchins along the south and southeast coasts was gradual, occurring over 2 or more years, whereas on the east coast it occurred within 1 or 2 years.

The dramatic decrease in abundance of sea urchins is reflected by the dwindling catches in recent years. The average catch rate reported by fishermen for the period when sea urchins were last abundant (late 1970's and early 1980's) was 78.7±37.7 shells per person per day (range=30-150 shells per person per day;

[2]Stephen Willoughby, Fisheries Division, Ministry of Agriculture and Natural Resources, Barbados. Personal commun.

[3]Tim Jones, sea urchin fisherman, Long Bay, Barbados. Personal commun.

[4]In 1986, $1.00 Bds = US $0.50.

Table 1.—The estimated period of decline in abundance of *Tripneustes ventricosus* around Barbados based on interviews with fishermen.

Area	Avg. year of decline	Range	No. of respondents
A. Silver Sands	1978	1973-81	11
B. Crane Beach/ Sam Lord's Castle	1979[1]	1975-83	12
C. East Coast	1982	1981-83	14

[1]Five respondents (not included) reported that the decline occurred in the late 1970's-early 1980's.

N=29 respondents). This is equivalent to about 8 liters (fresh roe) per person per day or 1,180 sea urchins per person per day. In contrast, all of the fishermen interviewed agreed that, at present, sea urchins are rare to absent on traditional fishing grounds. The average catch rate reported by those still fishing was 9.4±7.1 shells per person per day (range: 2-24 shells per person per day; N=9). This is equivalent to about 0.9 liters (fresh roe) per person day or 140 sea urchins per person per day.

Aside from this drastic decrease in the abundance of sea urchins, many fishermen also noted qualitative changes in the resource in recent years. Thirty-eight percent of respondents (N=34) claimed that the size of sea urchins that they fished had decreased, 34 percent (N=32) claimed that the amount of roe per sea urchin had decreased, and 49 percent (N=37) claimed that sea urchins had become less palatable, or "bitter", as the stock declined. Decreases in size, gonadal content, and palatability were attributed mainly to a reduction in the quantity and quality of algae ("moss") upon which the sea urchins feed.

Cause of the Decline

Sixty-two percent of the fishermen interviewed believed that pollution was the major cause of, or contributing factor to, the *T. ventricosus* decline in Barbados. Many felt that pollution acted to reduce algae, an important source of food and a shelter for juvenile sea urchins. Some claimed that herbicides used in the sugar cane industry killed off sea urchins in areas of freshwater runoff (e.g., Conset Bay and Bath). Others blamed oil pollution and effluents from hotels, such as chlorinated swimming pool water. A few felt that erosion of the coastline, due to the formation of sea walls and groins, had caused increased sedimentation and a reduction in algal cover.

Figure 3.—Marketing of *Tripneustes ventricosus* in Barbados. From left to right: The traditional "shell" with a sea grape leaf cone, shell with leaf removed to show test filled with roe, and an intact sea urchin. All specimens are about 6 cm in horizontal test diameter.

Twenty-two percent of fishermen claimed that overfishing was the cause of the decline of sea urchin stocks. The remaining 16 percent cited various other factors including fishing with dynamite, offshore migration of the sea urchins, and disease.

Rehabilitation

When fishermen were asked what could be done to rehabilitate the sea urchin fishery, 42 percent of respondents (N=31) suggested a total ban on fishing for 1-5 years, and 29 percent called for stricter enforcement of the closed season. Twenty-three percent felt that the government should investigate means of reestablishing sea urchin stocks, including transplantation of reproductive individuals to depleted areas. Two of the respondents recounted previous transplantation efforts, initiated by sea urchin fishermen in the 1950's, in which populations were reestablished via recruitment in artificially restocked areas. Scheibling and Johnson (1985) relate a similar account.[5]

[5]Copies of reports to the Fisheries Division of Barbados are available from the senior author upon request.

Socioeconomic Impact of the Decline

The collapse of the sea urchin fishery of Barbados has resulted in a major loss of employment. Most of the fishermen interviewed claimed that they now fished less frequently or had stopped altogether. Table 2 shows a dramatic decline in the estimated number of sea urchin fishermen in three major fishing areas. Estimates of numbers of fishermen in the past (i.e., when sea urchins were last abundant) are only rough approximations. Many of the fishermen interviewed simply stated that there were "innumerable" people fishing sea urchins in the past. The Fisheries Division of Barbados has estimated that the number of people employed by the sea urchin fishery has been reduced from "over 1,000" in the early 1970's to "less than 100" at present.[6]

Sixty-three percent of the responding fishermen (N=30) claimed that sea urchins, when abundant in the past, accounted for a major portion (>50 percent) of their yearly income. The average (±S.D.) weekly income reported was $386 Bds (±164) per week (range: $100-700 Bds; N=29 respondents) during the fishing season. This closely approximates an indirect estimate of $395 Bds per week based on the estimated catch rate (79 shells per person per day and fishing frequency (5 days per week) given above, and assuming a previous market value of $1 Bds per shell (in about 1980). In contrast, 77 percent of the fishermen reported they presently (1985-86 season) had no income from this fishery, and the remaining 23 percent claimed that sea urchins accounted for only a minor portion (<25 percent) of their yearly income. The average present income reported was $21 Bds per week (range: $0-100 Bds, N=34 respondents). Therefore, despite the dramatic rise in market value of sea urchin roe over the last 5 years, there has been a serious loss of employment income from sea urchin fishing.

The collapse of the sea urchin fishery is expected to place additional pressure on other resources, most notably flying fish, as sea urchin fishermen attempt to compensate for their loss of income. The flying fish and sea urchin fisheries appear to have been complementary: 68 percent of the sea urchin fishermen interviewed also fished flying fish. Most indicated that they usually stopped sea urchin fishing around the middle of December when the flying fish season began. Twenty percent also earned income from spear fishing and shell collecting, 5 percent from farming, and 7 percent from miscellaneous jobs.

Table 2.—Estimated numbers of sea urchin fishermen in three major fishing areas around Barbados, both before and after the decline in sea urchin abundance. Data are means, with ranges and sample sizes (number of respondents) in parentheses, based on interviews with fishermen.

Area	Number of fishermen		
	Pre-decline	Post-decline	% decrease
A. Silver Sands/ Oistins	150 (100-300;5)	7 (0-12;7)	95
B. Sam Lord's Castle/Long Bay	46 (30-100;4)	11 (5-25;7)	76
C. Skeete's Bay/ Conset Bay	41 (20-100;6)	3 (0-8;9)	93

Aside from the loss of employment and income, the collapse of the sea urchin fishery represents the loss of an important food resource. Barbadians have long cherished sea urchin roe as a traditional delicacy (Nutting, 1919). It may be eaten raw, fried with seasoning, steamed, or baked in a pudding. Seventy-two percent of the consumers interviewed (N=60) rated sea urchin roe as "good" (28 percent) or "excellent" (44 percent), i.e., a "3" or "4" rating, respectively, on our 4-point scale. The average numerical rating was 3.0. Positive evaluations generally were based on taste and nutritional value, although three (male) respondents intimated that consumption of sea urchin roe enhanced sexual performance. Seventy-two percent of the consumer respondents (N=53) believed that sea urchin roe was an important component of their diet in the past. Only 15 percent of the consumers either did not like the roe or found it otherwise unacceptable (rating "1"). One-third of these consumers abstained from eating sea urchin roe for religious reasons.

When consumers were asked to compare sea urchin roe with fish, 30 percent preferred the roe over most (8 percent) or all (22 percent) fish, i.e., a rating of "4" or "5" respectively on our 5-point scale. Fifty-eight percent of consumers liked sea urchin roe as much as fish (rating "3"). The average numerical rating was 2.9.

All consumers interviewed noted that sea urchin roe had become much less available and much more expensive in recent years. In the past, the roe was eaten an average of 4 days per week (N=35 respondents). In contrast, 69 percent of consumers (N=33 respondents) in 1986 claimed that they now no longer ate sea urchin roe and 23 percent ate it only 1 day per week.

The consumers sampled in this study lived in the northern part of Barbados, an area distant from the main sea urchin fishing areas around the south and southeast coasts. Therefore, our estimates of sea urchin roe consumption may be lower than that for consumers in the southern part of the country. Although sea urchin fishermen may represent a bias in the other direction, 98 percent of those interviewed (N=40) ate the roe and considered it a delicacy. Ninety-three percent of the fishermen claimed that they ate the roe whenever they caught sea urchins. Eighty-eight percent reported that all, or nearly all, members of their family ate sea urchin roe, and 10 percent reported that most members of their family ate it.

Discussion

Decline in Sea Urchin Abundance

As revealed by fishermen interviews, there has been a major decline in *T. ventricosus* abundance at Barbados over the past decade. Recent surveys of traditional fishing grounds have confirmed fishermen's reports that these sea urchins are rare to absent in areas where they were once extremely plentiful (Scheibling and Johnson, 1985; Scheibling et al.,

[6]Stephen Willoughby, Fisheries Division, Barbados. Personal commun.

1985). A few localized aggregations of *T. ventricosus* still exist in some of the more remote and inaccessible areas. Densities within these aggregations range from 0.4 to 3.8 individuals/m^2, which may be indicative of natural densities of these sea urchins in the absence of intensive fishing pressure (Schcibling and Johnson, 1985). At other islands where they are not fished, average densities of *T. ventricosus* in seagrass, *Thalassia testudinum*, beds ranged from 0.6 to 1.2 individuals/m^2 (Scheibling, 1982; Keller, 1983; Tertschnig, 1985). Comparative data on the abundance of *T. ventricosus* at Barbados in the past are lacking, although fishermen frequently reported that they were so abundant "that it would be difficult to place one's hand upon the bottom without touching a sea urchin."

There is evidence of past declines in the Barbadian *T. ventricosus* fishery. In the late nineteenth century, complaints about declining numbers of sea urchins prompted the government to pass the Sea Egg Preservation Act of 1879 which prohibited fishing during what was believed to be the spawning period, April to August (Bair, 1962). This legislation was reinforced by the Fisheries Regulation Act of 1904-05, again in response to complaints of decline, with more severe penalties (fines and imprisonment) for the fishing, sale, or purchase of sea urchins during the closed season (Bair, 1962).

Fourteen of the fishermen we interviewed recalled previous declines in the abundance of *T. ventricosus* along the south or east coasts, which they placed between 20 and 40 years ago. However, they also noted that sea urchins were scarce only for 1 or 2 years, after which they returned to former levels of abundance. Brown (1942) reported that the 1941 season "was a poor one."

Between 1954 and 1957, Lewis (1958) studied a population of *T. ventricosus* near Speightstown on the west coast of Barbados. Although sea urchins were abundant and commercially exploited along parts of the west coast at that time[7], they have since all but disappeared. With the elimination of the west coast populations, sea urchin fishing was limited largely to the south and east coasts. The recent decline of sea urchin populations in these latter areas marks the culmination of a long-term trend which now extends islandwide.

Cause of the Decline

An understanding of the factors which have brought about the *T. ventricosus* decline in Barbados is of crucial importance in assessing the potential for recovery of the fishery. The spatial and temporal pattern of depopulation suggests that overfishing has been a major cause of, or contributing factor to, the demise of these sea urchins. The decline in sea urchin populations seems to have occurred initially in the most accessible areas and spread progressively to more remote areas. It is quite possible that once sea urchin populations were depleted on the sheltered west coast, fishing intensified firstly along the south coast and then along the more exposed southeast, east, and north coasts, as fishermen ventured further afield in search of exploitable stocks. The gradual decline in *T. ventricosus* along the south and southeast coasts in the late 1970's was followed by a rapid decline on the east coast in the early 1980's due to a dramatic increase in fishing pressure on the only remaining populations.

To estimate the extent of fishing pressure on *T. ventricosus* in the early 1970's we made the following assumptions based on interview data: 1) There were 500 sea urchin fishermen (this is about twice the average number given for three major centers in Table 2 and about half of the number estimated by the Fisheries Division, Barbados); 2) on average 71.5 percent of these fishermen were fishing during the first 4 months of the season (September to December, Table 1); 3) each fished an average of 5 days per week; and 4) the average catch rate was 1,180 sea urchins per person per day. This gave an estimate of 34 million sea urchins caught during the height of the season. We then assumed that this represented about 75 percent of the total annual catch (which included catches during the other 4 months of the season as well as closed season fishing) to give an estimated total catch of 45 million sea urchins per year. To estimate the areal extent of the sea urchin fishing grounds, we multiplied the length of the coastline between Silver Sands and Bath, 34 km (measured by digitizing the coastline on a map of scale 1:50,000), by 1 km, the estimated average offshore range of *T. ventricosus*. This gave an estimated area of 34 km^2. Dividing the estimated annual catch by this area gives a catch density of 1.3 individuals per m^2, which seems to be a reasonable reflection of the predecline level of abundance. Although these calculations are only crude approximations, they do indicate that sea urchin populations were subjected to intense fishing pressure in the past.

Interestingly, although only 22 percent of the fishermen that we interviewed believed that overfishing was the cause of the decline in sea urchins, 71 percent thought that strict regulatory measures, such as a total ban on fishing or rigid enforcement of the closed season, would enable the stock to recover.

Most fishermen felt that pollution has caused the decline in *T. ventricosus*, either directly or indirectly by reducing the abundance of seaweeds and sea grasses. Although pollution of coastal habitats by terrestrial effluents is a growing problem in Barbados (Lewis, 1985; Tomascik and Sander, 1985), sea urchin populations have been depleted in areas (such as the southeast and east coast) which are remote from major sources of pollution. Moreover, the existence of dense populations of these sea urchins in areas that are least accessible to fishermen also points to overfishing rather than pollution as a major factor. It seems likely, however, that a general deterioration in habitat quality, due to chemical pollution, siltation, dynamiting, and other anthropogenic changes in the environment, may have reduced the resilience of sea urchin populations to intensive fishing, thereby precipitating the catastrophic decline that occurred over the past decade.

In 1983, an outbreak of disease caused mass mortalities of another sea urchin, *Diadema antillarum*, at Barbados (Hunte et al., 1986) and throughout the

[7]J. B. Lewis, Redpath Museum, McGill University, Montreal, Que., Can. Personal Commun.

Caribbean (Lessios et al., 1984a). A few of the fishermen that we interviewed claimed to have seen *T. ventricosus* with characteristic symptoms of disease (extensive spine loss, loss of attachment to the substratum), although these observations were not coincident with the *D. antillarum* die-off. In other parts of the Caribbean, *T. ventricosus*, *T. williamsi*, and other sea urchin species apparently were unaffected by the disease which devastated *D. antillarum* (Lessios et al., 1984b). In any event, the major *T. ventricosus* decline in Barbados preceded the 1983 epizootic and cannot be attributed to it.

Recruitment and Recovery

The potential for recovery of *T. ventricosus* populations in Barbados is contingent upon recruitment via planktonic larvae. Unfortunately, information on recruitment and early life history of this species is lacking. Lewis (1958) found that recruitment was seasonal in Barbados. Metamorphosing larvae were common in the plankton between June and August, and recently settled juveniles were abundant in September. Lewis inferred a planktonic larval period of about 1 month based on the occurrence of successive larval stages in a series of plankton samples. This is consistent with our recent laboratory studies (Mladenov and Scheibling, unpubl. data) and those of Mortensen (1921), in which cultured larvae took 3-4 weeks to reach a final stage of development, although metamorphosis has not been observed in laboratory cultures.

The relatively long planktonic larval stage (probably greater than 1 month) increases the likelihood of long-distance dispersal of *T. ventricosus* by ocean currents. Barbados receives oceanic water from the Amazon River region, via the Guiana current, and from the North Equatorial Current (Borstad, 1982). Therefore, larvae recruiting in Barbados may originate from populations off the coast of South America. Alternatively, local oceanographic features, such as eddy systems (Emery, 1972), may retain even long-lived larvae from local populations in the vicinity of Barbados.

Clearly these alternatives have important implications for assessing the potential for recovery and in formulating future management strategies. If recruits originate from local breeding populations, then overfishing these populations, especially during the peak spawning period, would lead to an accelerated decline in stocks. Conversely, if recruits are derived from distant populations, fishing of local stocks should not have as great an impact, unless the presence of adults enhances larval settlement and/or postmetamorphic survival (Tegner and Dayton, 1977).

Tripneustes ventricosus juveniles may occur in habitats differing from those of adults. Off Sam Lord's Castle, we found juveniles on sand flats, whereas adults occupied rubble reefs (Scheibling and Johnson, 1985; Scheibling et al., 1985). Lewis (1958) found recently settled *T. ventricosus* juveniles under rocks and in crevices in shallow rock flats on the west coast of Barbados. Aggregations of juveniles also have been found in shallow wave-exposed areas in the Bahamas (Moore et al., 1963) and in St. Croix, U.S. Virgin Islands (Scheibling, personal observ.), and in seagrass beds in Bermuda (McPherson, 1965; Tertschnig, 1985).

Predation on juveniles may be important in limiting recruitment to adult populations of *T. ventricosus*. The cryptic behaviour of juveniles presumably is a means of avoiding visual predators such as fish. Keller (1983) found that recruitment of *T. ventricosus* in seagrass beds at Jamaica occurred only in cages which excluded fish. Barbadian fishermen report that reef fish, particularly the queen triggerfish, *Balistes vetula*, are important predators of juvenile *T. ventricosus*, and this could account for the scarcity of juveniles on reefs where adults are abundant. The rapid growth rate of juveniles may enable *T. ventricosus* to escape in size from fish predators. Lewis (1958) showed that *T. ventricosus* attained reproductive maturity at 40-60 mm test diameter and grew 60-80 mm in their first year. A better understanding of recruitment patterns and factors influencing growth and survival of the early life history stages of *T. ventricosus* is imperative for the formulation of sound management policies and assessment of the potential for recovery of the sea urchin fishery.

Rehabilitation

The occurrence of dense aggregations of *T. ventricosus* in a few remote areas around Barbados (Scheibling and Johnson, 1985) suggests that large populations of sea urchins can be reestablished in coastal habitats, at least along the less developed southeast and east coasts. For this to occur, remedial measures should be implemented to prevent any further depletion of the resource and to facilitate the recovery of populations. Such measures may include: 1) A moratorium on sea urchin fishing for at least 1 year, 2) establishment of reserves where sea urchin fishing is prohibited, and 3) strict enforcement of the closed season.

Although most of the fishermen agreed that such measures could potentially rehabilitate the sea urchin fishery, they also expressed grave doubts that they could be enforced. The general feeling was that one could not prevent a poor man, whose livelihood depended on his catch, from fishing sea urchins as long as they were available. The sporadic and apparently unsuccessful attempts of the government to impose a closed season attest to the difficulties of acceptance and enforcement of such regulatory measures.

An alternative approach would be to artificially enhance *T. ventricosus* recruitment by aquacultural techniques. Larvae and early juvenile stages could be reared in the laboratory and juveniles could be released in large numbers in selected natural habitats or protective enclosures in the field (e.g., cages or rafts). Techniques for rearing *T. ventricosus* larvae are being developed (Mladenov et al., 1985, Mladenov and Scheibling, unpubl. data), and juveniles have been grown in the laboratory and in field enclosures on a variety of algal foods (Lewis, 1958; Lilly, 1975). Moreover, fishermen claim to have successfully restocked areas by transplanting breeding adults. Therefore, in our view, artificial stock enhancement through aquaculture presents a feasible and promising means of rehabilitating the fishery in areas

where pollution and food supply are not limiting factors.

The recent collapse of the sea urchin fishery in Barbados has socioeconomic ramifications which transcend the loss of employment and hardship for the fishermen and their families. Many Barbadians consider the loss of this traditional food source as an historical and cultural tragedy. The fundamental concern, however, is the loss of a nutritious staple food.

Clearly, both basic and applied research are needed to investigate the potential for rehabilitation of this sea urchin fishery. Although the need for such research is probably more pressing now than ever, it initially was advocated by C. C. Nutting (1919) almost 70 years ago:

> There is no doubt that this sea-egg is a valuable food product, being exceedingly nutritious and quite palatable; and it is now the basis of an industry of no mean proportion and might by judicial legal and scientific encouragement be greatly enlarged, much to the advantage of our friends, the Barbadians. A laboratory for the scientific investigation of the problem of protection, based on a better knowledge of the life history of the species, could easily be established....and pay for itself many times over in a rational control and encouragement of the industry.

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Literature Cited

Bair, R. A. 1962. The Barbados fishing industry. Ph.D. Thesis, McGill Univ., Montreal, Quebec, 85 p.

Borstad, G. A. 1982. The influence of the meandering Guiana Current and Amazon River discharge on surface salinity near Barbados. J. Mar. Res. 40:421-434.

Brown, H. H. 1942. The sea fisheries of Barbados. Development and welfare in the British West Indies. Bull. 1, Barbados, 141 p.

Emery, A. R. Eddy formation from an oceanic island: Ecological effects. Caribb. J. Sci. 12:121-128.

Hunte, W., I. Cote, and T. Tomascik. 1986. On the dynamics of mass mortality of *Diadema antillarum* in Barbados. Coral Reefs 4:135-139.

Keller, B. D. 1983. Coexistence of sea urchins in seagrass meadows: An experimental analysis of competition and predation. Ecology 64:1581-1598.

Lessios, H. A., D. R. Robertson, and J. D. Cubit. 1984a. Spread of *Diadema* mass mortality through the Caribbean. Science 276:335-337.

_____, J. D. Cubit, D. R. Robertson, M. J. Shulman, M. R. Parker, S. D. Garrity, and S. C. Levings. 1984b. Mass mortality of *Diadema antillarum* on the Caribbean Coast of Panama. Coral Reefs 3:173-182.

Lewis, J. B. 1958. The biology of the tropical sea urchin *Tripneustes esculentus* Leske in Barbados, British West Indies. Can. J. Zool. 36:607-621.

_____. 1985. Groundwater discharge onto coral reefs, Barbados (West Indies). Proc. 5th Int. Coral Reef Congress, Tahiti 6:477-481.

Lilly, G. R. 1975. The influence of diet on the growth and bioenergetics of the tropical sea urchin, *Tripneustes ventricosus* (Lamarck). Ph.D. Univ. Brit. Columbia, Vancouver, Ph.D. Thesis, 216 p.

Mann, K. H., J. L. C. Wright, B. E. Welsford, and E. Hadfield. 1984. Responses of the sea urchin *Strongylocentrotus droebachiensis* (O. F. Muller) to water-borne stimuli from potential predators and potential food algae. J. Exp. Mar. Biol. Ecol. 79:233-244.

McPherson, B. F. 1965. Contributions to the biology of the sea urchin *Tripneustes ventricosus*. Bull. Mar. Sci. 15:228-244.

Mladenov, P. V., R. E. Scheibling, and K. Brady. 1985. Development of the edible sea urchin *Tripneustes ventricosus*. Report to Fisheries Division, Ministry of Agriculture, Food and Consumer Affairs, Barbados, 18 p.

Moore, H. B., T. Jutare, J. A. Jones, B. F. McPherson, and C. F. E. Roper. 1963. A contribution to the biology of *Tripneustes esculentus*. Bull. Mar. Sci. 13:267-281.

Mortensen, T. H. 1921. Studies of the development and larval forms of echinoderms. G. E. C. Gad, Copenhagen, 261 p.

Nutting, C. C. 1919. Barbados-Antigua Expedition. Univ. Iowa Stud. Nat. Hist. VIII (3), 274 p.

Scheibling, R. E. 1982. Feeding habits of *Oreaster reticulatus* (Echinodermata:Asteroidea). Bull. Mar. Sci. 32:504-510.

_____ and S. C. Johnson. 1985. Assessment of sea egg (*Tripneustes ventricosus*) stocks in traditional fishing grounds in Barbados. Report to Fisheries Division, Ministry of Agriculture, Food and Consumer Affairs, Barbados, 35 p.

_____, P. V. Mladenov, and K. Brady. 1985. Density, size structure and reproductive condition of populations of sea eggs (*Tripneustes ventricosus*) at Sam Lords Castle, Barbados. Report to Fisheries Division, Ministry of Agriculture, Food and Consumer Affairs, Barbados, 17 p.

Sloan, N. A. 1985. Echinoderm fisheries of the world: A review. *In* B. F. Keegan and B. D. S. O'Conner (editors), Proceedings of the Fifth International Echinoderms Conference, Galway, Ireland, p. 109-124. A. A. Balkema, Rotterdam.

Snyder, N., and H. Snyder. 1970. Alarm response of *Diadema antillarum*. Science 168:276-278.

Tegner, M. J., and P. K. Dayton. 1977. Sea urchin recruitment patterns and implications of commercial fishing. Science 196:324-326.

_____, and L. A. Levin. 1983. Spiny lobsters and sea urchins: Analysis of a predator-prey interaction. J. Exp. Mar. Biol. Ecol. 73:125-150.

Tertschnig, W. P. 1985. Sea urchins in seagrass communities: Resource management as a functional perspective of adaptive strategies. *In* B. F. Keegan and B. D. S. O'Connor (editors), Proceedings of the Fifth International Echinoderm Conference, Galway, Ireland, p. 361-367. A. A. Balkema, Rotterdam.

Tomascik, T., and F. Sander. 1985. Effects of eutrophication on reef-building corals. I. Growth rate of the reef-building coral *Montastrea annularis*. Mar. Biol. 87:143-155.

Vadas, R. L., R. W. Elner, P. E. Garwood and I. G. Babb. 1986. Experimental evaluation of aggregation behavior in the sea urchin *Strongylocentrotus droebachiensis*. Mar. Biol. 90:443-440.

The 1986 Subsistence Harvest of Northern Fur Seals, *Callorhinus ursinus*, on St. Paul Island, Alaska

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Introduction

There has been no commercial harvesting of northern fur seals, *Callorhinus ursinus*, on the Pribilof Islands, Alaska, since the Interim Convention on Conservation of North Pacific Fur Seals expired in 1984. During 1985 and 1986, northern fur seals were harvested on St. Paul and St. George Islands to meet only the dietary (subsistence) needs of Aleut residents. A summary of the 1985 subsistence harvest on St. Paul Island is found in Zimmerman and Letcher (1986). This paper summarizes the 1986 harvest on St. Paul Island and contrasts the two years.

Methods

In 1985 data were collected on 1) the number of seals killed each day, 2) the weight of seal meat taken daily for human consumption, and 3) the daily percent use being made of seals. We collected the same data in 1986 except for the weight of meat being taken for human consumption. In 1985 the daily weight of seal meat being taken for human consumption was estimated by weighing a 25 percent sample of the meat immediately after butchering on the harvest field. Because the weighing of meat was viewed by St. Paul residents as an intrusive activity, seal meat was not weighed in 1986. Instead, the amount of meat being taken each day for human consumption was estimated by weighing approximately a 10 percent sample (range 6-16 percent; total number of samples = 117) of carcasses before and after butchering. The ratio of these values (individual carcass weights after butchering divided by individual carcass weights before butchering) was subtracted from 100 to determine the daily mean percent use which was being made of animals (i.e. number 3 above). These mean daily estimates of percent use were reduced by 5 percent to account for blood loss during the butchering process (Zimmerman and Letcher, 1986). This mean daily percent use value was then multiplied by the mean daily beginning weight of unbutchered animals, and then by the number of animals killed, to estimate the weight of meat taken each day for human consumption. An attempt was made to collect similar data during the subsistence harvest on St. George Island. Such a small number of seals were taken, however (124), and the butchering process proceeded so rapidly, that is was impossible for the single observer to obtain a representative number of unbiased samples.

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Results and Discussion

To provide labor for driving, stunning, and removing pelts from seals, several of the governmental entities on St. Paul Island (Tanadgusix Corporation, City of St. Paul, Tribal Government of St. Paul) volunteered small numbers of their paid staff to participate in the harvest each day. To avoid requests for overtime, harvest hours were scheduled to coincide with the end of each working day (2:00-4:30 p.m. each afternoon, Monday through Friday) rather than beginning at 5:00 a.m. which had been the traditional harvest time. The number of contributed individuals involved each day in the 1986 harvest seldom exceeded 12, substantially less than the approximately 30 persons employed in the 1985 harvest. Part of this decrease in labor occurred because no seal pelts were processed for potential commercial use in 1986, as they had been in 1985. Therefore, a processing plant crew was not used in the harvest.

In 1985 the average daily harvest was approximately 225 seals (Table 1). Meat not removed from the harvest field by individuals for immediate personal use in 1985 was taken to a processing building where it was either salted or frozen and then stored for future community use. Because there was very little demand for this community-stored meat during the months which followed, there was no community storage of meat during the 1986 harvest. Instead, the 1986 harvest was carried out on a daily demand basis. Each day's take in 1986 (Table 2; mean = 65 seals per day) was based on the number of orders placed with the Conservation Officer for the Tribal Government of St. Paul. The total number of seals taken in 1986 on St. Paul Island was only 38 percent (1,299; Table 2) of the number taken in 1985 (3,384; Table 1).

Animals taken in 1986 were significantly smaller (one-way ANOVA; $p < 0.01$) than those taken in 1985. The overall mean of carcass weights following lancing of the heart was 23.4 kg (51.7 pounds) in 1986; in 1985 the mean was 28.5 kg (62.8 pounds). This reduction in mean animal weight coincided with an apparent reduction in the mean age of animals harvested. There was a greater percentage of 2-year-old animals taken in 1986 (38 percent) than in 1985 (7 percent). Most of the animals taken during the 1985 harvest (78 percent) were 3-year-old animals. In 1986 3-year-old ani-

Table 1.—Northern fur seal 1985 subsistence harvest data, St. Paul Island, Alaska (from Zimmerman and Letcher, 1986).

Date	Area	No. of animals taken	Mean carcass plus pelt wt. (kg)	Total wt. of meat taken (kg)	Wt. of meat per animal taken (kg)	Percent use of entire animal after lancing heart
7/17	Northeast Point	200		2,594	13.0	
7/18	Polovina	200	28.4	2,490	12.4	43.8
7/19	Little Zapadni	197		2,482	12.6	
7/22	Zapadni	203	29.4	2,614	12.9	43.8
7/23	Reef	500	28.8	6,389	12.8	44.3
7/24	Northeast Point	202	28.7	2,400	11.9	41.5
7/25	Kitovi	200	27.3	2,588	12.9	47.4
7/26	Tolostol	200	28.5	2,499	12.5	43.8
7/29	Zapadni	200	29.9	2,245	11.3	37.9
7/30	Reef	200	27.8	2,598	13.0	46.8
7/31	Northeast Point	202	28.5	2,518	12.5	43.7
8/01	Polovina	225	28.2	2,950	13.1	46.5
8/02	Tolstol	216	29.5	2,802	12.9	44.0
8/05	Zapadni, L. Zap.	238	28.0	2,623	11.0	39.3
8/06	Zolotol	201	27.3	2,589	12.9	47.1
Totals		3,384	28.5	42,381	12.5	43.8%

Table 2.—Northern fur seal 1986 subsistence harvest data, St. Paul Island, Alaska

Date	Area	No. of animals taken	Initial carcass wt. (kg)	Total wt. of meat taken (kg)	Wt. of meat per animal taken (kg)	Percent use of entire animal after lancing heart
7/14	Reef	50	23.7	595	11.9	50.2
7/15	Zapadni	19	27.3	304	16.0	58.7
7/16	Little Zapadni	51	25.6	663	13.0	50.7
7/17	Polovina	51	25.8	675	13.2	51.3
7/18	Northeast Point	64	23.5	788	12.3	52.3
7/21	Reef	49	26.0	666	13.6	52.2
7/22	Lukanin	96	27.0	1,226	12.8	47.4
7/23	Little Zapadni	31	25.2	388	12.5	49.6
7/24	Polovina	54	23.1	641	11.9	51.3
7/25	Northeast Point	102	23.6	1,317	12.9	59.7
7/28	Reef	60	20.0	420	7.0	35.0
7/29	Lukanin	59	23.1	598	10.1	43.9
7/30	Little Zapadni	27	22.7	377	14.0	61.4
7/31	Polovina	33	21.8	241	7.3	33.5
8/01	Northeast Point	56	22.0	499	8.9	40.5
8/05	Reef	83	21.6	725	8.7	40.5
8/06	Zapadni	82	20.3	686	8.4	41.1
8/07	Little Polovina	80	23.7	898	11.2	47.4
8/08	Northeast Point	181	23.8	1,711	9.5	39.6
9/27	Little Zapadni	71	22.0	994	14.0	63.6
Totals		1,299	23.4[1]	14,412	11.1	47.2[2]

[1]Mean computed using all values (n=127) rather than by averaging daily means.
[2]Mean computed using all values (n=117) rather than by averaging daily means.

mals accounted for only 54 percent of harvested animals (Fowler[1]). We believe this reduction in size and age of harvested animals reflects an Aleut preference for younger animals for food. Greater selectivity in the size of animals to be killed was possible in 1986 because smaller numbers of animals were harvested from each pod.

The mean weight of meat taken per seal in 1986 was 11.1 kg (24.4 pounds), somewhat less than the 12.5 kg (27.5 pounds) per seal taken in 1985. This difference results from the decreased size of animals taken. Percent use of animals was not significantly higher (one-way ANOVA; $p = 0.07$) in 1986 (47.2 percent) than it was in 1985 (43.8 percent). However, there did appear to be an increase in the use of hind quarters in 1986. In 1985, the butchering was done by a harvest crew under the direction of a foreman. Consequently, butchering was quite uniform each day; shoulders, flippers, chests, hearts, livers, backbones and ribs were taken from each seal for human consumption. Very few hind quarters were taken in 1985, and no pelts, blubber, skulls or internal organs other than hearts and livers were consumed (Zimmerman and Letcher, 1986, described the butchering process). In 1986 butchering was done by individuals taking the meat for their own use. Although the quantity and types of meat butchered from carcasses by individuals in 1986 were less consistent than the quantity and types of meat which were butchered for community use in 1985, many individuals in 1986 were observed removing only the skull, pelt, blubber and internal organs and then taking the rest of the carcass intact along with the heart and liver.

The harvest in 1985 was terminated by Federal Regulation on 8 August (USDOC, 1985). In 1986, it was possible for each island to extend its harvest through 30 September (USDOC, 1986) providing subsistence needs had not been met and the number of female seals taken was less than 0.5 percent of the total number of animals killed. Although both islands applied for and were granted extensions, very little harvesting occurred during the 9 August-30 September period[2]. Only 71 seals were harvested during this period on St. Paul Island. All were taken on 27 September (Table 2)[3].

The estimated amount of meat taken

[1]Charles Fowler, National Marine Mammal Laboratory, National Marine Fisheries Service, NOAA, 7600 Sand Point Way N.E., Seattle, WA 98115. Personal commun.

[2]Residents of St. Paul Island had planned to continue harvesting during the extension period. However, in mid-August about 100 seals were found dead from unknown causes on St. George Island. Concern for the health of harvestable seals throughout the Pribilof Islands caused St. Paul residents to wait several weeks to see if an epidemic-type situation was developing which might cause the meat to be unfit for human consumption.

[3]The 1986 regulations (USDOC, 1986) specified that harvesting after 8 August had to be terminated if the total number of females taken exceeded 0.5 percent of all animals harvested. Residents of St. Paul Island terminated their harvest on 27 September because 12 of the 71 animals taken on that day were female, thereby putting the total number of females taken (15) over the 0.5 percent allowable female take.

on St. Paul Island for human consumption in 1986 was 14,412 kg (31,706 pounds). This was about one-third of the amount taken in 1985 (42,381 kg; 93,435 pounds). In 1985, however, only 28,800 kg of that total remained available for use on St. Paul Island after losses due to spoilage (3,400 kg), shipment to St. George Island (8,200 kg) and shipment to other Aleut communities (2,000 kg) were subtracted (Zimmerman and Letcher, 1986). Of this total, about 22,500 kg were frozen and 3,900 kg were salted. The remaining 2,400 kg are believed to have been taken directly from the harvest field for personal use. A survey of the St. Paul community freezer in March 1986 indicated that about two-thirds of the 22,500 kg of frozen meat from 1985 remained unused (estimated 15,000 kg). About one-third of the 3,900 kg of salted meat from 1985 was also unused at that time (estimated 1,300 kg). Most of this meat was later thrown away because it consisted of undesirable or untraditional cuts (ribs, backbones) or because it was perceived by St. Paul residents to have been handled and preserved under unsanitary conditions.

Thus, if no spoilage or export of meat from the 1986 harvest occurs, more meat from the 1986 harvest (14,412 kg) may be eaten than was consumed from the 1985 harvest (estimated 12,500 kg)[4]. Assuming that the permanent native population on St. Paul Island is 483 (USDOC, 1981), the 1986 harvest of 14,412 kg (31,700 pounds) would allow a theoretical average daily consumption of 0.08 kg (about 3 ounces) of seal meat (with bone) per person per day. This is less than the previous estimates of seal meat consumption in the Pribilof Islands which indicated a per capita consumption of about 1 pound per day (see review in Zimmerman and Letcher, 1986). Surveys conducted by the Tribal Government during the harvest extension period, however, indicated that only 359 more seals would have been required to meet the demands of St. Paul residents (Kozloff[5]). Harvesting this additional number of seals would only have resulted in an additional 4,000 kg of meat, or about 0.02 kg (less than 1 ounce) more meat per person per day.

[4]This 12,500 kg total is based on an estimated consumption of 7,500 kg of meat which was frozen by the community, an estimated consumption of 2,600 kg of meat which was salted by the community, and an estimated consumption of 2,400 kg of meat which was taken for personal use before the meat was stored by the community.

[5]Patrick Kozloff, Tribal Government of St. Paul, St. Paul Island, AK 99660. Personal commun.

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Literature Cited

USDOC. 1981. 1980 census of population, Volume I—Characteristics of the population, Chapter A—Number of inhabitants, Part 3—Alaska. U.S. Dep. Commer., Bur. Census, 40 p.

———. 1985. Subsistence taking of North Pacific Fur Seals. Action: Emergency interim rule and request for comment. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv. Fed. Regist. 50(130): 27914-27922 (Monday, 8 July, 1985).

———. 1986. Subsistence taking of North Pacific Fur Seals. Action: Emergency final rule. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv. Fed Regist. 51 (131): 24828-24841 (Wednesday, 9 July, 1986).

Zimmerman, S. T., and J. D. Letcher. 1986. The 1985 subsistence harvest of northern fur seals, *Callorhinus ursinus*, on St. Paul Island, Alaska. Mar. Fish. Rev. 48(1): 10-14.

U.S. Tuna Trade Summary, 1985

SAMUEL F. HERRICK, Jr., and STEVEN J. KOPLIN

Introduction

For the U.S. tuna industry, 1985 appeared to be a year of relative calm following 3 years of turmoil that saw the closure of four canneries in California and Hawaii, as well as a significant reduction in U.S. tuna harvesting capacity. Although not as tumultuous, 1985 was a continuation of recent trends characterized by further attrition of the U.S. tuna fleet, decreased cannery deliveries of domestically caught tuna, a decline in U.S. cannery production, and increased imports of canned tuna.

The development of significant new tuna fisheries in the Indian Ocean and the western Pacific Ocean and improved catch rates in traditional fishing areas in recent years are factors which have led to greatly increased supplies of raw tuna available through the international market. As a result, ex-vessel prices have fallen sharply to levels below what it costs to harvest tuna for many of the vessels in the U.S. fleet. The opportunity to reduce production costs by purchasing tuna through the international market, particularly at a time when revenues were being severely squeezed by intense competition from canned imports, moved U.S. processors to revise their raw tuna procurement strategies.

Historically, processors relied on close integration with the U.S. fleet to secure dependable supplies of low-cost tuna which were then supplemented through imports to meet processing requirements. With reliable supplies of tuna available from numerous sources outside the United States, however, long-term supply arrangements with the U.S. fleet are no longer as critical and processors have lessened their reliance on U.S. vessels. Confronted by reduced cannery support and by ex-vessel prices below the vessel's breakeven production level, many vessels were compelled to leave the fleet. By the close of 1985, the U.S. tropical tuna fleet had experienced a 15 percent loss in number and a 12 precent reduction in carrying capacity and, for the first time in recent history, no new vessels entered the fishery.

With the reduction in domestic processing capacity that occurred during 1984, U.S. cannery receipts[1] of imported and domestically caught albacore, *Thunnus alalunga* (white meat) and tropical (light meat) tunas (skipjack tuna, *Euthynnus pelamis*; yellowfin tuna, *T. albacares*; blackfin tuna, *T. atlanticus*; bluefin tuna, *T. thynnus*; and bigeye tuna, *T. obesus*) fell sharply in 1985. The total volume was 468,956 short tons (tons), a decrease of 11 percent in total volume from 1984 and 15 percent below the 1980-84 average volume of annual cannery receipts (Table 1). Cannery deliveries by domestic vessels amounted to 213,808 tons in 1985, 16 percent below deliveries for 1984 and 14 percent below the 5-year average from 1980 to 1984 (Table 1). Raw tuna imports made up the 255,145-ton balance in total cannery supplies for 1985, a 5 percent decrease in imports from 1984 and 16 percent below the 1980-84 annual average for imports. Direct exports[2] of domestically caught tuna totaled 34,797 tons in 1985, up 7 percent from 1984 and 324 percent greater than the 5-year average. When exports of domestically caught tuna are combined with domestic deliveries to U.S. canneries, total U.S. deliveries amounted to 248,605 tons for 1985, 13 percent less than the corresponding amount for 1984 and 4 percent less than the 5-year average.

The western Pacific Ocean[3] was the predominant production area for the U.S. fleet in 1985, providing 129,431 tons or 52 percent of the domestically caught cannery receipts and direct exports for the year (Table 2). Total domestically caught deliveries from this area decreased 31 percent from 1984, however, and as a share of total domestically caught deliveries by oceanic area, western Pacific deliveries decreased 21 percent from 1984. The western Pacific was also the area from which most of the raw tuna imports originated in 1985—74,356 tons, or 29 percent of total imports by oceanic area (Table 3).

The decrease in western Pacific fishing activity by the U.S. fleet during 1985 can be largely attributed to prevailing economic conditions and increased yields of yellowfin tuna in the eastern Pacific Ocean following the El Niño conditions of 1982-83. The lowest ex-vessel prices in 5 years, particularly for skipjack tuna, and exceptionally good fishing for yel-

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[1]Cannery receipts include only tuna destined for U.S. canneries. Cannery receipts exclude U.S.-caught tuna landed at foreign sites, U.S.-caught tuna landed at U.S. sites that is destined for foreign canneries, U.S.-caught tuna destined for the fresh-fish market, tuna imported as flakes, imported tuna not fit for human consumption, and imported "sushi" grade tuna.

[2]In this report, exports include tuna landed directly in or transshipped to a foreign country; excludes tuna exported from the U.S. east coast.

[3]The eastern and western Pacific for this report are distinguished at long. 150°W.

Table 1.—U.S. tuna cannery receipts (short tons) by processing site and direct exports, 1980-85.

Species	California/American Samoa/Hawaii							Puerto Rico						
	1980	1981	1982	1983	1984	1985	80-84 Avg.	1980	1981	1982	1983	1984	1985	80-84 Avg.
Domestic														
Albacore	8,078	14,855	6,965	10,466	10,323	5,608	10,137	20	2		4	3,565	1,245	718
Skipjack tuna	99,386	83,880	82,669	113,465	94,152	66,716	94,711	15,781	13,950	18,781	41,608	51,441	17,304	28,312
Yellowfin tuna[1]	100,523	100,117	93,468	90,052	59,907	35,365	88,813	18,693	26,049	24,800	30,044	35,193	87,571	26,956
Subtotal	207,987	198,852	183,102	213,983	164,382	107,689	193,661	34,494	40,001	43,581	71,656	90,199	106,120	55,986
Imported[2]														
Albacore	37,664	43,241	33,928	22,750	21,962	20,030	31,909	46,147	44,056	60,670	50,105	70,882	75,122	54,372
Skipjack tuna	103,556	72,189	45,837	50,633	28,737	18,026	60,190	105,075	115,820	82,178	84,675	106,136	74,606	98,777
Yellowfin tuna[1]	36,091	39,293	17,811	14,081	12,685	10,169	23,993	38,382	44,295	33,402	24,251	29,045	57,192	33,874
Subtotal	177,311	154,723	97,576	87,464	63,384	48,225	116,092	189,604	204,171	176,250	159,031	206,063	206,920	187,023
Grand total	385,298	353,575	280,678	301,447	227,766	155,914	309,753	224,098	244,172	219,831	230,687	296,262	313,040	243,009

Species	Direct exports[3]							Total						
	1980	1981	1982	1983	1984	1985	80-84 Avg.	1980	1981	1982	1983	1984	1985	80-84 Avg.
Domestic														
Albacore			62		108		34	8,098	14,857	7,027	10,470	13,996	6,853	10,889
Skipjack tuna	918	292	387	45	15,388	19,669	3,406	116,085	98,122	101,837	155,118	160,981	103,689	126,429
Yellowfin tuna[1]	1,339	1,087	3,864	538	16,980	15,128	4,762	120,555	127,253	122,132	120,634	112,080	138,064	120,531
Subtotal	2,257	1,379	4,313	583	32,476	34,797	8,202	244,738	240,232	230,996	286,222	287,057	248,606	257,849
Imported[2]														
Albacore								83,811	87,297	94,598	72,855	92,844	95,152	86,281
Skipjack tuna								208,631	188,009	128,015	135,308	134,873	92,632	158,967
Yellowfin tuna[1]								74,473	83,588	51,213	38,332	41,730	67,361	57,867
Subtotal								366,915	358,894	273,826	246,495	269,447	255,145	303,115
Grand total	2,257	1,379	4,313	583	32,476	34,797	8,202	611,653	599,126	504,822	532,717	556,504	503,751	560,964

[1]Includes bigeye, blackfin, and bluefin tuna.
[2]Includes only imported tuna destined for canning; excludes tuna imported as flakes, tuna not fit for human consumption, and "sushi" grade tuna.
[3]Includes tuna landed directly or transshipped to a foreign country; excludes tuna exported from the east coast.
Source: Statistics and Market News, Southwest Region, NMFS, NOAA.

Table 2.—U.S. domestic tuna cannery receipts and direct exports[1] (short tons) by ocean of origin, 1980-85 (none from Indian Ocean).

Species	Albacore							Skipjack tuna						
	1980	1981	1982	1983	1984	1985	80-84 Avg.	1980	1981	1982	1983	1984	1985	80-84 Avg.
E. Atlantic	2	2	62				13	2,458	3,327	27	21			1,167
W. Atlantic	18	4		4		1	5	25	108		3	944	2,079	216
E. Pacific	7,690	13,954	5,099	9,434	13,409	6,021	9,917	101,344	74,116	59,264	40,181	22,359	4,992	59,453
W. Pacific	388	897	1,866	1,032	587	831	954	12,258	20,571	42,546	114,913	137,678	96,618	65,593
Total	8,098	14,857	7,027	10,470	13,996	6,853	10,889	116,085	98,122	101,837	155,118	160,981	103,689	126,429

Ocean	Yellowfin tuna[2]							Total						
	1980	1981	1982	1983	1984	1985	80-84 Avg.	1980	1981	1982	1983	1984	1985	80-84 Avg.
E. Atlantic	1,898	1,966	1,087				990	4,358	5,295	1,176	21			2,170
W. Atlantic	517	502	115	70	1,550	4,185	551	560	614	115	77	2,494	6,265	772
E. Pacific	116,947	110,251	96,640	65,863	60,753	101,897	90,091	225,981	198,321	161,003	115,478	96,521	112,910	159,461
W. Pacific	1,193	14,534	24,290	54,701	49,777	31,982	28,899	13,839	36,002	68,702	170,646	188,042	129,431	95,446
Total	120,555	127,253	122,132	120,634	112,080	138,064	120,531	244,738	240,232	230,996	286,222	287,057	248,606	257,849

[1]Includes tuna landed directly or transshipped to a foreign country; excludes tuna exported from the east coast.
[2]Includes bigeye, blackfin, and bluefin tuna.
Source: Statistics and Market News, Southwest Region, NMFS, NOAA.

lowfin tuna (the light meat species that commands the highest ex-vessel price in both domestic and foreign markets) led to a resurgence of U.S. fishing in the eastern Pacific Ocean during 1985. A record catch of yellowfin tuna (218,920 tons)

Table 3.—U.S. imported tuna cannery receipts[1] (short tons) by ocean of origin, 1980-85.

Ocean	Albacore							Skipjack tuna						
	1980	1981	1982	1983	1984	1985	80-84 Avg.	1980	1981	1982	1983	1984	1985	80-84 Avg.
E. Atlantic	14,567	17,105	19,815	16,935	27,392	30,655	19,163	40,318	67,011	49,417	34,358	35,882	10,828	45,397
W. Atlantic	15,016	16,894	21,129	16,127	17,209	25,486	17,275	6,546	8,754	17,119	18,070	9,059	20,650	11,910
E. Pacific	418	22	48	243	439		234	23,981	9,409	11,916	4,501	9,245	17,148	11,810
W. Pacific	36,808	43,638	35,374	23,226	32,340	28,667	34,277	132,283	95,119	44,017	72,742	72,699	30,427	83,372
Indian	17,002	9,638	18,232	16,324	15,464	10,344	15,332	5,503	7,716	5,546	5,637	7,988	13,581	6,478
Total	83,811	87,297	94,598	72,855	92,844	95,152	86,281	208,631	188,009	128,015	135,308	134,873	92,632	158,967

Ocean	Yellowfin tuna[2]							Total						
	1980	1981	1982	1983	1984	1985	80-84 Avg.	1980	1981	1982	1983	1984	1985	80-84 Avg.
E. Atlantic	6,589	19,561	9,320	4,618	3,258	5,075	8,669	61,474	103,677	78,552	55,911	66,532	46,558	73,229
W. Atlantic	2,194	5,200	3,058	6,446	3,259	10,910	4,031	23,756	30,848	41,306	40,643	29,527	57,046	33,216
E. Pacific	30,891	16,039	19,200	7,492	9,222	29,572	16,569	55,290	25,470	31,164	12,236	18,906	46,718	28,613
W. Pacific	34,060	41,340	18,800	18,814	23,799	15,262	27,363	203,151	180,097	98,191	114,782	128,838	74,356	145,012
Indian	739	1,448	835	962	2,192	6,542	1,235	23,244	18,802	24,613	22,923	25,644	30,467	23,045
Total	74,473	83,588	51,213	38,332	41,730	67,361	57,867	366,915	358,894	273,826	246,495	269,447	255,145	303,115

[1]Includes only imported tuna destined for canning; excludes tuna imported as flakes, tuna not fit for human consumption, and "sushi" grade tuna.
[2]Includes bigeye, blackfin, and bluefin tuna.
Source: Statistics and Market News, Southwest Region, NMFS, NOAA.

was reported from the Inter-American Tropical Tuna Commission's yellowfin regulatory area. The U.S. fleet accounted for almost 39 percent of the eastern Pacific yellowfin tuna catch in 1985, an amount representing the largeset contribution to domestically caught light meat tuna cannery receipts by oceanic area for the year.

The loss of west coast and Hawaii processing capacity and a significant increase in imports of foreign packed tuna contributed to a decrease in overall U.S. canned tuna production (27.9 million standard cases[4]) of 11 percent from 1984 (Table 4). When canned imports were combined with U.S. production, the total addition to U.S. canned supplies in 1985 was 38.9 million standard cases, a 2 percent decline from that in 1984 (Table 4). Canned imports set a new record in 1985, reaching 11.0 million standard cases. This represents a 32 percent increase from 1984 and an increase of 237 percent since 1980. Imports were dominated by tuna packed in water which is subject to a much lower import duty than tuna packed in oil.

Table 4.—U.S. supply of canned tuna, volume and value, 1975-85.

Year	Domestic production[2] White	%	Light	%	Canned imports[3]	%	Total
	Case pack supply (1,000 standard cases)[1]						
1975	5,296	17.8	21,854	73.3	2,650	8.9	29,800
1976	6,312	18.7	24,416	72.3	3,020	9.0	33,748
1977	6,559	21.9	21,544	72.1	1,776	6.0	29,879
1978	7,528	19.4	28,615	73.8	2,655	6.8	38,798
1979	6,129	17.7	25,678	74.3	2,754	8.0	34,561
1980	5,825	17.1	25,049	73.4	3,259	9.5	34,133
1981	6,204	17.3	25,948	72.5	3,633	10.2	35,785
1982	6,416	20.0	21,199	66.0	4,491	14.0	32,106
1983	5,444	14.9	24,844	68.0	6,273	17.1	36,561
1984	7,012	17.6	24,489	61.5	8,324	20.9	39,825
1985	6,764	17.4	21,185	54.4	10,972	28.2	38,921
	Case pack value ($1,000)						
1975	136,678	19.6	515,957	73.8	45,951	6.6	698,586
1976	212,869	23.1	640,594	69.6	67,502	7.3	920,965
1977	240,734	25.3	665,880	70.0	44,658	4.7	951,272
1978	296,506	22.2	976,754	73.0	63,822	4.8	1,337,082
1979	243,851	20.9	859,998	73.6	65,071	5.5	1,168,920
1980	252,290	20.3	891,237	71.9	97,254	7.8	1,240,781
1981	294,292	22.8	885,846	68.6	110,359	8.6	1,290,497
1982	275,400	26.7	643,046	62.3	113,346	11.0	1,031,792
1983	197,011	19.8	661,586	66.4	137,324	13.8	995,921
1984	255,997	24.6	616,280	59.3	167,268	16.1	1,039,545
1985	269,887	26.2	550,882	53.5	209,138	20.3	1,029,907

[1]For ease of comparison a standard case will represent 48 6.5-ounce cans or 19.5 pounds.
[2]Sources: U.S. Department of Commerce. 1976-86. Fisheries of the United States, 1976-85. Curr. Fish. Stat. 6900, 7200, 7500, 7800, 8000, 8100, 8200, 8300, 8320, 8360, 8380. Var. pagin. U.S. Department of Commerce. 1975-85. Canned fishery products, 1975-84. Curr. Fish. Stat. 6701, 6901, 7201, 7501, 7801, 8001, 8101, 8201, 8301, 8319, 8359. Var. pagin.
[3]Source: U.S. Department of Commerce, Bureau of the Census computerized data files, 1974-85.
[4]A percent symbol (%) denotes the percent of total for each canned category.

Two pieces of legislation aimed at eliminating the tariff difference between

[4]For ease of comparison, a standard case will consist of 48 6.5-ounce cans or 19.5 pounds. In 1985, processors began packing albacore (white meat) tuna in 6.5 ounce cans rather than 7.0 ounce cans. Therefore, a standard case of white meat tuna decreased from 21.0 pounds to 19.5 pounds.

imports of canned tuna in water and canned tuna in oil were introduced into the U.S. House of Representatives during 1985. In a related matter, the U.S. Trade Representative called on the International Trade Commission (ITC) to conduct a "332 investigation" on the competitive conditions within the U.S. tuna industry. The ITC had completed, in 1984, a "201 investigation" of canned tuna imports in response to a petition from certain segments of the U.S. tuna industry seeking tariff relief from imports of canned tuna packed in water[5].

The U.S. consumer continued to benefit from competition between foreign and domestically produced canned tuna. The retail composite canned tuna price, which decreased 3 percent during 1984, fell an additional 2 percent in 1985. The downward price trend contributed to corresponding growth in overall apparent consumption which increased about 3 percent in 1985, following a 2 percent increase for all of 1984. Sales of water-packed products (except in the health/diet category) increased 6 percent in 1985. Since water-packed products account for more than 60 percent of total sales, this increase helped offset reduced sales of tuna in oil and of health/diet canned tuna products.

U.S. consumers are also developing a taste for fresh and fresh-frozen tuna products. Fresh albacore tuna has become increasingly popular in the restaurant and retail trade. There is also a growing domestic market for high quality, fresh tropical tuna species, which has stimulated development of fresh-fish tuna fisheries on the U.S. east and west coasts, in the Gulf of Mexico, and in Hawaii.

In the following sections we review the 1985 production of white and light meat tuna by the U.S. tuna industry and consumption of tuna products by U.S. consumers. In the final section the economic performance of the U.S. tropical tuna purse seine fleet is analyzed over the period 1979-83. Unless otherwise noted, the information and data presented herein were compiled by the Statistics and Market News Section of the Southwest Region, National Marine Fisheries Service (NMFS).

Albacore Production

Albacore, which is the only species that may be canned as white meat tuna in the United States[6], accounted for about 24 percent of total U.S. canned production in 1985. According to industry reports, consumption of canned white meat tuna packed in water had increased 2 percent in 1985, while consumption of canned white meat packed in oil, which had shown a gain for 1984, fell 4 percent during 1985. Total cannery receipts—domestically caught albacore plus imports—reached 102,005 tons in 1985, 5 percent below receipts for 1984 but 5 percent above the 1980-84 average (Table 1). Domestic white meat production for 1985 amounted to 6.8 million standard cases (Table 4), 4 percent below production in 1984.

Cannery Receipts of Domestically Caught Albacore

The U.S. albacore fishery presently occurs almost entirely in the Pacific Ocean north of lat. 25°N and offshore from the west coast to about long. 180°. This area is divided at long. 140°W into offshore (mid-Pacific) and inshore fishing areas. Troll (jig) gear is the dominant gear used in the U.S. fishery.

As a result of the 1984 cannery closures, U.S. albacore fishermen opened the 1985 season faced with the virtual disappearance of their usual markets. This was refelcted in the volume of domestically caught albacore delivered to U.S. canneries in 1985 which totaled 6,853 tons, 51 percent below the corresponding figure for 1984. This represents the lowest volume over the last 5 years (Table 1). The loss of cannery markets, particularly in Hawaii, resulted in only 17 vessels participating in the mid-Pacific albacore fishery during 1985, a 62 percent decrease in the number from 1984. However, even with a reduced number of vessels, 825 tons of domestically caught albacore cannery receipts were landed in Hawaii and transshipped to California, an increase of 40 percent from 1984. Receipts of domestically caught albacore from the inshore area decreased 55 percent from 1984 which, in view of relatively unchanged catch rates from 1984, reflects a significant decrease in inshore fishing effort.

Compounding the difficulties brought about by the U.S. cannery closures was a generally abundant supply of albacore being offered through the international market during 1985, a situation which had contributed to a significant decline in ex-vessel prices by mid-year. For domestically caught albacore delivered to U.S. canneries, contract prices started out at $1,300 per ton for fish 9 pounds or greater, and $950 per ton for fish under 9 pounds, decreases of 7 and 15 percent, respectively, from prices at the beginning of 1984. By the end of the year prices had fallen to $1,000 per ton for large fish and $800 per ton for small fish, the lowest they have been in the past 5 years (Table 5).

With the substantial decline in both domestically caught receipts and ex-vessel prices, aggregate ex-vessel revenue from the 1985 albacore fishery fell 56 percent from that of 1984. Dividing ex-vessel albacore revenue by total cannery deliverries of U.S.-caught albacore yields a weighted ex-vessel price of $1,087 per ton for 1985 which is a 13 percent drop from 1984 (Table 6).

Considering the diminished opportunities for direct sales to U.S. canneries, domestic albacore fishermen continued to explore alternative opportunities for marketing their catches. The potential for fresh albacore sales was recognized in 1982 when fishermen started selling albacore off their boats after U.S. procesors had drastically curtailed their purchases of domestically caught fish. From this early, fragmented effort grew a more concerted attempt on the part of the albacore sector of the U.S. tuna industry to develop alternatives to the cannery market with emphasis on the development of fresh and fresh-frozen albacore products for the retail and restaurant trade.

The National Marine Fisheries Service has supported development of the U.S. albacore fishery through the Saltonstall-

[5]See S. F. Herrick, Jr., and S. J. Koplin. 1985. U.S. tuna trade summary, 1984. Admin. Rep. SWR-85-6. Southwest Region, National Marine Fisheries Service, NOAA, Terminal Isl., Calif.

[6]21 U.S. Code of Federal Regulations. Section 161.190 (a) (4) (i). U.S. Gov. Print. Off. 1985).

Table 5.—U.S. cannery ex-vessel (contract) prices (dollars per short ton) at California and Puerto Rico, 1980-85.

	Albacore			Skipjack tuna				Yellowfin tuna				
Year	>18 lb.	9-18 lb.	<9 lb.	>7.5 lb.	4-7.5 lb.	3-4 lb.	<3 lb.	>20 lb.	7.5-20 lb.	4-7.5 lb.	3-4 lb.	<3 lb.
1980	1,610	1,610	1,610	850	850	700	545	950	950	810	810	810
	1,635	1,635	1,635	1,100	1,100	1,000	800	1,200	1,200	1,100	1,100	1,100
1981	1,800	1,800	1,800	1,100	1,100	1,000	800	1,200	1,200	1,100	1,100	1,100
1982	1,425	1,425	1,425	1,100	1,100	1,000	800	1,200	1,200	1,100	1,100	1,100
				1,040	1,040	940	740	1,140	1,140	1,040	1,040	1,040
	1,350	1,225	1,000	890	890	700	500	1,170	1,050	890	890	890
1983[1]				950	850	700	420	1,230	1,050	850	700	420
	1,250	1,250	975	900	800	640	420	1,125	990	800	640	400
				880	780	585	250	1,125	975	780	585	250
1984[1]	1,400	1,400	1,125	830	730	500	250	1,085	950	730	500	250
				850	750	550	250	1,000	900	750	550	250
	1,150-1,300	1,150-1,300	875-1,025	763	650	470	235	925	800	650	470	235
1985[1]				708	610	435	200	865	753	610	435	200
	1,300	1,300	950	738	640	500	275	870	758	640	500	275
	1,150	1,150	800	650	590	490	290	815	715	590	490	290
	1,000	1,000	800	700	630	500	300	825	725	630	500	300

[1]Skipjack and yellowfin tuna prices are for standard grade; prices may vary due to quality.
Source: Statistics and Market News, Southwest Region, NMFS, NOAA.

Table 6.—U.S. cannery ex-vessel (weighted) prices (dollars per short ton), 1980-85.

	Albacore		Skipjack tuna		Yellowfin tuna	
Year	Nominal	Real[1]	Nominal	Real[1]	Nominal	Real[1]
1980	1,659	930	1,063	596	1,180	661
1981	1,800	920	1,030	527	1,170	598
1982	1,387	669	965	465	1,123	542
1983	1,268	589	799	371	1,032	479
1984	1,252	560	760	340	982	440
1985	1,087	469	622	269	820	354

[1]Adjusted for inflation using GNP implicit price deflator (1972=100).
Source: Statistics and Market News, Southwest Region, NMFS, NOAA.

Kennedy Program[7]. Over the last 4 years more than $530,000 in Saltonstall-Kennedy fishery development funds has been awarded to the albacore fishery, almost half of which has been earmarked for research on increasing opportunities for fresh and fresh-frozen albacore consumption. Much of this research has been directed toward upgrading handling and processing techniques to provide a product suitable for the fresh fish market. Other research has been aimed at developing different albacore products.

According to industry sources, about 1,200 tons of domestically caught albacore were channeled through the albacore alternative marketing program during 1985 (W. Perkins, Western Fishboat Owners Association, personal commun.). Ex-vessel prices reportedly ranged from under $1,000 per ton to $1,300 per ton with an average of $1,200 per ton, which was 10 percent higher than the weighted average cannery price.

In addition to sales through the alternative fresh fish market, almost 700 tons of domestically caught albacore was exported during 1985 to France, Japan, and Thailand[8] (G. K. Alameda, Ocean Venture, Inc., personal commun.). There appears to be a strong potential for expanding albacore exports to Japan where it is processed for Japan's canned tuna market. Like the U.S. market for fresh albacore, the key to success in exporting to Japan is the ability to provide high quality fish, because the Japanese are extremely sensitive about the aesthetic and gustatory qualities of the canned tuna they consume.

Production of Canned White Meat Tuna

The primary U.S. tuna receiving and processing sites during 1985 were Mayaguez and Ponce, Puerto Rico; San Pedro, Calif.; Honolulu, Hawaii; and Pago Pago, American Samoa. For reporting purposes, tuna receipts and production data are combined for American Samoa, California and Hawaii (AmS/Ca/Hi). Data for Puerto Rico are reported separately[9].

Seventy-five percent of the raw albacore supplied to U.S. canneries in 1985 (102,005 tons) was delivered to canneries in Puerto Rico and the balance to canneries in AmS/Ca/Hi. This represented a 3 percent increase from 1984 in albacore deliveries to Puerto Rico and a 21 percent decline in deliveries to AmS/Ca/Hi. Of the total 1985 domestically caught albacore receipts, 82 percent, or 5,608 tons, was received in AmS/Ca/Hi and the remainder, 1,245 tons, was transshipped from west coast ports to canneries in Puerto Rico (Table 1). This was a 46 percent reduction from 1984 in domestically caught albacore deliveries to AmS/Ca/Hi, and a 65 percent decrease in domestically caught albacore transshipments to Puerto Rico.

U.S. cannery receipts of imported raw albacore totaled 95,152 tons in 1985, a 2

[7]The Saltonstall-Kennedy Act (15 U.S.C. 713c-2-713c-3) makes available to the Secretary of Commerce up to 30 percent of the gross receipts collected under the customs laws from duties on fishery products. The Secretary must use at least 60 percent of these funds each year in the form of grants to assist persons in carrying out research and development projects which address any aspect of U.S. fisheries.

[8]U.S. albacore exports do not appear under direct exports in Table 1 because albacore exported in 1985 was initially landed in the United States and then exported through brokers. Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

[9]Although no tuna was processed in Hawaii during 1985, Hawaii was a receiving/transshipping site for tuna destined for U.S. canneries in 1985. Tuna transshipped through Hawaii during 1985 is recorded as a receipt at its cannery destination. The AmS/Ca/Hi designation is maintained for 1985 in order to make historical comparisons.

Table 7.—Cannery imports of frozen tuna (short tons) by country of origin, 1980-85.

	1980		1981		1982		1983		1984		1985	
Origin[1]	White	Light[2]	White	Light	White	Light	White	Light	White	Light	White	Light
Brazil	109	5,847	83	5,968	1,443	16,181	1,185	15,154	2,018	7,743	710	15,282
Canary Island	362		325		1,693	1	7,653	5	14,030	10	9,415	16
Caymen Island				2,171		6,723				9,960		11,031
Ecuador	340	10,661						2,809		12,034		18,722
Ghana	70	30,071	760	36,188	1,078	27,783	345	23,751	170	6,640		
Ivory Coast		12,860	345	35,805		27,862		13,783	289	30,997		15,887
Japan	3,957	45,112	6,483	12,307	5,834	12,705	696	18,426	10,946	20,965	6,754	718
Mauritius	4,349		1,364	152	4,811		4,668		5,026		5,789	
Netherl. Antilles	6,611	4,869	6,202	273	10,054	1,996	8,560	258	9,619	298	12,110	197
Panama		27,660		23,746		29,558	1	8,110	424	13,928		15,138
Philippines	37	26,799		20,781		5,923		6,476		1,327		
Reunion	9,209	157	4,738	204	12,036	146	7,438	3	4,363	67	1,521	756
Seychelles								3,042		8,257	262	17,064
Singapore	3,444	5,366	3,969	7,781	1,386	3,846	4,217	3,761	5,024		2,562	
Solomon Island	1,088	18,984		22,618		928		10,600		15,836		3,390
South Africa	14,136	263	15,091	1,832	17,044	1	7,304	239	11,856	1,478	21,101	
South Korea	412	925	1,547	4,893	1,001	6,891	5,374	13,830	2,119	11,064	8,874	9,747
Taiwan		244	1,730	169	99	384	5,075	3,851	9,739	9,468	5,947	10,592
Uruguay	7,903	1,719	9,920	1,489	8,835	670	4,480	143	3,228	722	7,425	1,997
Venezuela		865	394	5,496		2,421	1	6,604		7,002	147	33,538
Other	31,784	90,702	34,346	89,724	29,285	35,209	15,858	42,795	13,993	18,807	12,535	5,918
Totals	83,811	283,104	87,297	271,597	94,599	179,228	72,855	173,640	92,844	176,603	95,152	159,993

[1]Data reflects the origin of shipments and not necessarily the flag of the catcher vessel.
[2]Light meat includes bigeye, blackfin, bluefin, skipjack, and yellowfin tuna.
Source: Statistics and Market News, Southwest Region, NMFS, NOAA.

percent increase from 1984 (Table 1). Imports accounted for 93 percent of the 1985 total cannery supply of albacore compared with 87 percent in 1984. Puerto Rico was the major receiving site for imports with 75,122 tons or 79 percent of total albacore imports; AmS/Ca/Hi received the remainder. Albacore imports received in Puerto Rico during 1985 increased 6 percent from 1984, while imports received in AmS/Ca/Hi decreased 9 percent. The leading exporter of raw albacore to U.S. canneries in 1984 was South Africa[10], a major transshipping base for Japanese and Taiwanese albacore vessels, with 21,101 tons or 22 percent of the total imports (Table 7).

Imports of raw albacore received at U.S. canneries in 1985 were valued at about $153 million[11], up 6 percent from 1984. Dividing this value by the corresponding volume yields a weighted average import price of $1,611 per ton for raw albacore in 1985, nearly 3 percent above that for 1984.

In 1985, 55 percent of the total U.S. cannery supply of raw albacore came from the Atlantic Ocean, followed by the Pacific and Indian Oceans which contributed 35 and 10 percent, respectively, to the total supply. Virtually all of the albacore received from the Atlantic and Indian Oceans consisted of imports. Receipts of albacore from the Atlantic Ocean increased 26 percent from 1984, those from the Pacific decreased 24 percent, and those from the Indian Ocean fell 33 percent (Tables 2 and 3).

During 1985, wholesale list prices for U.S.-produced, nationally-advertised brands of white meat tuna ranged between $55.57 and $60.63 per standard case. With discounts, the actual selling price at wholesale was as low as $45.20 for a standard case which, when considering the decrease in size of a standard case, represented an increase of 7 percent over 1984. Production of both advertised and private brands of white meat tuna was valued at about $270 million (free on board plant value) in 1985, up 5 percent from 1984. Based on total white meat volume, the weighted average value in 1985 was $39.89 per standard case compared with $36.51 for the equivalent size case in 1984, a 9 percent increase.

Production of Light Meat Tuna

Although U.S. consumption of all light meat tuna products showed an overall increase in 1985, production of canned light meat tuna by U.S. processors during 1985 decreased considerably from 1984. In 1985, consumption of oil-packed, light meat tuna decreased 3 percent, but consumption of canned, light meat tuna packed in water increased nearly 7 percent based on relative market shares. This led to an overall increase in light meat consumption of about 4 percent for 1985. Cannery production of all light meat products totaled 21.2 million standard cases in 1985, a decrease of 13 percent from 1984. (Table 2). The total cannery supply of raw light meat tuna for 1985 was 366,949 tons, down 12 percent from 1984 (Table 1). Prices of light meat tuna at the ex-vessel, wholesale, and retail levels continued to decline during 1985.

Cannery Receipts of Domestically Caught Light Meat Tunas

The U.S.-flag, tropical tuna fleet consisted of 130 vessels with an overall carrying capacity of 113,394 tons at the beginning of 1985: 109 purse seiners and 21

[10]The exporting country reflects origin of shipments and not necessarily the flag of the catcher vessel.
[11]The values of raw imported tuna (white and light meat) provided herein are based on the average prices reported by importers to the Bureau of the Census, and volumes of imports compiled by the Statistics and Market News Service, NMFS Southwest Region.

baitboats (pole and line gear). By the end of 1985 the fleet had declined to 110 vessels, 92 purse seiners and 18 baitboats with a total carrying capacity of 99,594 tons, a 12 percent decrease from 1984. However, 36 of these 110 vessels were listed as inactive, and 21 of the inactive vessels were seiners having individual carrying capacities of 400 tons or more.

During 1985, the fleet operated almost exclusively in the Pacific Ocean. There were 39 vessels active in the western Pacific at the beginning of 1985 with a combined carrying capacity of 47,345 tons. The number in the western Pacific declined to 33 by the end of 1985 with a capacity of 40,675 tons, a 15 percent decrease in number and a 14 percent decrease in total capacity. Forty-three vessels with a total carrying capacity of 36,544 tons operated in the eastern Pacific during the first quarter of 1985, declining to 42 vessels with a capacity of 34,709 tons by the end of the year. This represented a decrease of 2 percent in the number of vessels and a decrease of 5 percent in carrying capacity. Only four U.S.-flag vessels, having a combined capacity of 4,380 tons, fished in the Caribbean area of the Atlantic Ocean during 1985.

Receipts of domestically caught, light meat tuna at U.S. canneries totaled 206,956 tons in 1985, 14 percent below receipts for 1984. This total comprised 84,020 tons of skipjack tuna and 122,936 tons of yellowfin tuna (includes bigeye, bluefin, and blackfin tuna), a decrease of 35 percent in skipjack deliveries and an increase of 30 percent in yellowfin deliveries from 1984. As indicated previously, improved yellowfin tuna fishing in the eastern Pacific, and economic conditions were major factors contributing to the substantial shift from skipjack to yellowfin in deliveries by the fleet during 1985. In addition to deliveries to U.S. canneries, U.S. flag vessels exported 34,797 tons of light meat tuna to foreign canneries in 1985, up 7 percent from 1984 (Table 1).

At the beginning of 1985, contract ex-vessel prices (without quality adjustments[12]) for light meat in all species and size categories were sharply below corresponding prices for 1984 and, except for the smaller size categories (skipjack and yellowfin four pounds or less), year-end prices were lower than opening prices (Table 5). The observed increase in contract price for smaller light meat tuna can perhaps be ascribed to a greater demand for smaller tuna at offshore processing sites where, for a given quantity of canned product, the relatively low cost of the additional labor required to process comparatively lower yielding small fish results in an overall cost saving.

Receipts of domestically caught skipjack tuna were valued at $52 million in 1985, down 53 percent from 1984. This yields a weighted ex-vessel price of $622 per ton, an 18 percent decrease from 1984. Domestic deliveries of yellowfin tuna generated about $101 million in ex-vessel revenue for 1985, 8 percent above 1984. The weighted ex-vessel price for yellowfin tuna in 1985 was $820 per ton, a decrease of 17 percent from 1984 (Table 6). Total ex-vessel revenue was approximately $153 million in 1985, 25 percent less than 1984 ex-vessel revenue.

Production Of Canned Light Meat Tuna

In the United States, skipjack, yellowfin, bigeye, and bluefin tuna are collectively canned as light meat tuna. The 6.5-ounce can of chunk style, light meat tuna in water was the most popular tuna product consumed in the U.S. during 1985, accounting for over 43 percent of all tuna sales.

During 1985, 366,949 tons of raw, light meat tuna were delivered to U.S. canneries in Puerto Rico, American Samoa, and California (Table 1). Puerto Rico received 236,673 tons in 1985, 64 percent of the total; the balance, 130,276 tons, was received at canneries in American Samoa and California. Total receipts for Puerto Rico increased 7 percent from 1984 and decreased 33 percent for American Samoa and California (Table 1) reflecting the loss of west coast processing capacity that occurred during 1984.

Domestically caught, light meat tuna deliveries to canneries in Puerto Rico during 1985 reached 104,875 tons, 51 percent of the total domestically caught, light meat deliveries for 1985. The remainder, 102,081 tons, went to canneries in American Samoa and California. Compared with 1984, domestically caught, light meat tuna deliveries to Puerto Rico increased 21 percent, while deliveries to American Samoa, California, and Hawaii decreased 34 percent (Table 1). Imports of light meat tuna totaled 159,993 tons in 1985, 9 percent below the level of imports for 1984. Imports made up 44 percent of the total cannery supply in 1985 vs. 42 percent in 1984. Puerto Rico was the major receiving site for imports during 1985, accounting for 131,798 tons (82 percent of the total), a 3 percent decrease from 1984 (Table 1). Skipjack tuna made up 58 percent of the 1985 light meat imports with yellowfin tuna providing the balance. Overall, skipjack tuna imports were down 31 percent from 1984, while yellowfin tuna imports increased 61 percent.

Venezuela was the top exporter of raw light meat tuna to the United States in 1985 with 33,538 tons, 21 percent of the 1985 total. Ecuador followed with 18,722 tons, 12 percent of the total (Table 7).

Light meat imports in 1985 were valued at $127 million, down 7 percent from 1984. The value of skipjack tuna imports was about $66 million and the value of yellowfin tuna imports was about $61 million, a decrease from 1984 of 31 percent for skipjack tuna and an increase of 45 percent for yellowfin tuna. These values convert to weighted average prices of $708 per ton for imported skipjack tuna and $902 per ton for imported yellowfin tuna, an increase of about 1 percent and a decrease of 11 percent, respectively, from 1984.

The Pacific Ocean was the primary source of all light meat tuna cannery receipts and U.S. exports of light meat tuna in 1985 which totaled 401,746 tons. The Pacific provided 327,896 tons or 82 percent of this total, the Atlantic Ocean 13 percent, and the Indian Ocean 5 percent. On a regional basis, the western Pacific was the leading production area with 174,289 tons, 43 percent of total receipts and U.S. exports, even though total cannery receipts and direct exports from this area decreased 39 percent from 1984. Of the total receipts originating in the western Pacific during 1985, 74 percent

[12]Contract prices may be adjusted for salt content, temperature of the fish, and physical condition of the fish at unloading.

(128,600 tons which includes U.S. exports) was domestically caught and the remainder (45,689 tons) consisted of imports. Skipjack tuna was the predominant species in the western Pacific. Other oceanic regions contributing to the 1985 U.S. cannery supply and U.S. raw exports, in order of importance, were the eastern Pacific (primarily domestically caught yellowfin tuna), the western Atlantic, and the eastern Atlantic. For the first time, the Indian Ocean surpassed the eatern Atlantic as a source of light meat imports during 1985. This is a direct reflection of the shift by the Spanish and French fleets from their traditional eastern Atlantic waters into the western Indian Ocean. A breakdown of the 1984 cannery supply and U.S. exports by ocean of origin is given in Tables 2 and 3.

The wholesale list price of U.S. produced, advertised, light meat tuna ranged between $34.20 and $43.45 a standard case, but with discounts the price fell as low as $27.50 a case during the year. Total production of canned light meat tuna, both advertised and private label brands, was valued at $551 million (FOB plant value) in 1985, down 11 percent from 1984. This results in a weighted average value of $26.00 for a standard case of light meat tuna in 1985, an increase of 3 percent from 1984.

Canned Imports

Foreign processed canned tuna packed in oil is subject to a 35 percent tariff and therefore imports are negligible. Foreign processed canned tuna not in oil is under a tariff rate quota which allows imports of up to 20 percent of the previous year's domestic production, excluding American Samoa, to enter at 6 percent ad valorem; imports above the quota level enter at 12.5 percent ad valorem. Imports from American Samoa are not counted against the quota. Before the quota on canned imports not in oil is reached, the Bureau of the Census categorizes white meat and light meat imports separately. However, once the quota is reached, the Bureau of the Census no longer distinguishes between white and light meat imports. Thus, year-end figures comprise imports of both canned light and white meat not in oil.

In 1985, the quota on canned imports not in oil was 97.5 million pounds or 5.0 million standard cases. Total imports reached a record 214.3 million pounds or about 11.0 million standard cases, an increase of 32 percent from 1984 (Table 4). When the 1985 quota was reached on 7 May 1985, white meat made up 13 percent of the imports of canned tuna not in oil. Imports of canned tuna in oil, practically all light meat tuna, totaled 302,000 pounds or about 16,000 standard cases, an increase of 14 percent from 1984.

The leading exporter of canned tuna to the United States in 1985 was Thailand with 122.6 million pounds or 6.2 million standard cases. This was 57 percent of total imports and represents a 37 percent increase in imports from Thailand over 1984. The Philippines was a distant second with 30.8 million pounds or 1.6 million standard cases, 14 percent of the 1985 total.

Imports in 1985 were valued at about $209 million FOB, an increase of 25 percent from 1984. This converts to a weighted average price of $0.98 per pound or $19.11 per standard case which is 5 percent below that for 1984. The wholesale price, ex-warehouse New York, for skipjack tuna packed in Thailand ranged from $23.00 to $26.00 per standard case in 1985. Imports of canned tuna and their corresponding value by major exporting country are shown in Table 8.

Consumption

Consumption of canned tuna products in the United States for 1985 (excluding noncivilian consumption) was calculated to be 3.3 pounds per capita, 3 percent above 1984. An informal survey of industry members indicates that tuna was consumed at a ratio of about 20 percent white meat to 80 percent light meat. Based upon these figures, per capita consumption was about 0.66 pounds of white meat tuna and 2.64 pounds of light meat tuna. This converts to 1.6 standard cans of white meat tuna and 6.5 standard cans of light meat tuna per capita. When compared with consumption in 1984, based on the same consumption pattern, there was no change in white meat consumption and a 3 percent increase in light meat consumption.

Based on the National Marine Fisheries Service's "Operation Price Watch," (1984, 1985)[13] consumers paid an average of $1.42 per 6.5 ounce can for white meat tuna and $0.84 per 6.5 ounce can for light meat tuna during 1985 (although retail loss-leader promotions sometimes reduced light meat prices to $0.39 per can), a decrease of 3 percent for white and 2 percent for light meat from 1984. This resulted in an increase in estimated per capita expenditures on canned tuna in 1985—$7.73 compared with $7.54 in 1984.

Over the last several years, production and consumption of fresh bluefin, bigeye, and yellowfin tuna in the United States have increased substantially as evidenced by the rapid development of fresh fish fisheries off the U.S. east and west coasts, in the Gulf of Mexico, and in Hawaii. While these fisheries have mainly developed to meet a growing export demand for top-quality, sushi grade tuna, domestic demand also has increased with the growth of specialty seafood outlets and "sushi bars" in U.S. metropolitan areas.

Off the U.S. east coast, from Maine to Virginia, Atlantic bluefin tuna are harvested primarily for export to Japan. The Atlantic bluefin tuna fishery is highly regulated and catch quotas (by fish size and harvesting gear) are imposed through the International Commission for the Conservation of Atlantic Tunas. In 1985, U.S. fishermen, using a variety of gears including purse seine, longline, rod and reel, and handlines, landed 1,400 tons of Atlantic bluefin tuna. About 85 percent of the 1985 landings of "sushi" grade giant bluefin tuna caught using purse seine and longline gear was exported to Japan, with the remainder going to U.S. fresh fish markets (Northeast Fisheries Center, NMFS, personal commun.).

Spurred by a strong Japanese export market and increasing domestic demand, Atlantic and Gulf coast fishermen are directing more fishing effort to bigeye and yellowfin tuna. In 1985, domestic bigeye tuna landings destined for fresh consumption were about 370 tons, which exceeded 1984 landings by 9 percent. Fish-

[13]Operation Price Watch is based on an informal monthly survey of fish and other items in three retail grocery stores in each of 10 cities.

ermen received as much as $12,000 a ton for large, high-quality bigeye tuna exported to Japan in 1985 (Southeast Fisheries Center, NMFS, personal commun.). Landings of yellowfin tuna from both the southeast U.S. coast and Gulf of Mexico fisheries were also on the rise during 1985. Preliminary reports placed landings at 1,862 tons, with average ex-vessel prices ranging from $1,500 to $7,000 a ton depending on size and quality. This compares with landings of 565 tons at an average price of $2,080 per ton in 1984 (Southeast Region, NMFS, personal commun.).

A domestic fresh fish fishery for Pacific bluefin tuna on the U.S. west coast is also starting to develop. Landings in 1985 approached 610 tons and were valued at about $904,000. This fishery was almost nonexistent in 1984. Most of the west coast fresh bluefin tuna landings in 1985 were delivered to area restaurants. Besides supplying a strong local market, the Hawaiian fresh fish tuna fishery also delivers much of its catch to continental and export markets. Landings of fresh tuna from Hawaii totaled 2,950 tons worth $6.6 million in 1984. In 1985, U.S. imports of fresh tuna, primarily yellowfin, received in California amounted to 1,109 tons with a value of $5.8 million. This compares with imports of 871 tons having a value of $2.9 million in 1984.

Performance of the U.S. Purse Seine Fleet

Although changes in cannery deliveries, canned tuna production, prices, value, and consumption are useful indicators of conditions within the U.S. tuna industry, these measures form an incomplete picture in assessing the economic performance of the industry, because economic performance is also affected by the costs of producing output. Therefore, indicators that reflect changes in industry output and output prices over time relative to corresponding changes in input usage and input costs would provide a more complete picture of economic performance. To accomplish this, we developed a set of indices that account for changes in cannery deliveries, ex-vessel prices, inputs consumed, and input prices to examine relative changes in the economic performance of the U.S. tropical tuna purse seine fleet over the period 1979-83. The procedures used follow those reported in Norton et al. (1985) where the economic well-being of several different U.S. fishing fleets is evaluated over time through an overall performance index that incorporates changes in per unit output price, changes in input prices, and changes in fleet pro-

Table 8.—U.S. imports for consumption by principal sources tuna in airtight containers (oil and water).

Source	1980	1981	1982	1983	1984	1985
Quantity (1,000 pounds)						
Canada			2	2,106		88
Ecuador					890	5,175
Indonesia		146	595	2,634	2,222	1,388
Japan	24,794	21,271	26,481	20,387	26,855	23,703
Malaysia	66	696	755	3,083	1,608	3,878
Philippines	13,777	21,451	27,631	32,018	22,225	30,797
South Korea	127	31	49	68	82	58
Spain[1]	146	170	120	133	214	336
Taiwan	15,947	15,771	10,704	18,710	17,935	23,472
Thailand	6,405	10,315	18,667	39,930	89,685	122,666
Other	2,291	1,001	2,575	3,260	597	2,387
Total	63,553	70,852	87,579	122,329	162,313	213,948
Value (1,000 dollars)						
Canada			5	2,986		75
Ecuador					837	4,676
Indonesia		209	699	2,679	2,102	1,186
Japan	42,015	36,453	38,561	24,643	29,186	28,142
Malaysia	76	1,230	1,242	4,068	1,893	4,498
Philippines	20,043	30,504	31,085	32,291	20,396	25,930
South Korea	189	58	79	69	75	58
Spain[1]	367	402	300	268	376	560
Taiwan	23,316	24,631	14,366	22,772	22,475	29,801
Thailand	8,875	15,400	22,711	43,259	89,253	111,852
Other	2,373	1,471	4,299	4,289	677	2,360
Total	97,254	110,358	113,347	137,324	167,270	209,138
Unit value (per pound)						
Canada			$2.96	$1.42		$0.86
Ecuador					$0.94	0.90
Indonesia		$1.43	1.18	1.01	0.95	0.85
Japan	$1.69	1.71	1.46	1.20	1.09	1.19
Malaysia	1.14	1.77	1.64	1.32	1.18	1.16
Philippines	1.45	1.42	1.12	1.00	0.92	0.84
South Korea	1.48	1.86	1.63	1.02	0.91	0.99
Spain[1]	2.52	2.36	2.50	2.01	1.76	1.66
Taiwan	1.46	1.56	1.34	1.21	1.26	1.27
Thailand	1.39	1.49	1.22	1.08	1.00	0.91
Other	1.04	1.47	1.66	1.31	1.14	0.99
Average	1.53	1.56	1.29	1.12	1.03	0.98
Percentage of total quantity						
Canada			***	2		***
Ecuador					1	2
Indonesia		***	1	2	1	1
Japan	39	30	30	17	17	11
Malaysia	***	1	1	2	1	2
Philippines	22	30	32	26	14	14
South Korea	***	***	***	***	***	***
Spain[1]	***	***	***	***	***	***
Taiwan	25	22	12	15	11	11
Thailand	10	15	21	33	55	57
Other	4	2	3	3	***	2
Total	100	100	100	100	100	100

***Less than 1 percent, included in "Other" listing.
[1]Mainly oil packed.
Source: Department of Commerce, Bureau of the Census.

ductivity based on catch per unit of effort. For this study we constructed a composite purse seine fleet performance index from an aggregate output price index, an aggregate input price index, and a total factor productivity index.

The aggregate output price index in year "t" (t represents any of the years 1979-83) is the weighted average of the ratios of the ex-vessel prices for skipjack and yellowfin tuna in year "t" to their ex-vessel prices in 1979, the base year. The prices for skipjack and yellowfin tuna are the weighted ex-vessel prices described above. The weights used to compute the aggregate output price index in year "t" are the relative contributions of skipjack and yellowfin tuna revenues to total ex-vessel revenue in that year. Table 9 shows the price data and revenue share data used in calculating the aggregate output price index; the aggregate output price index is shown in Figure 1.

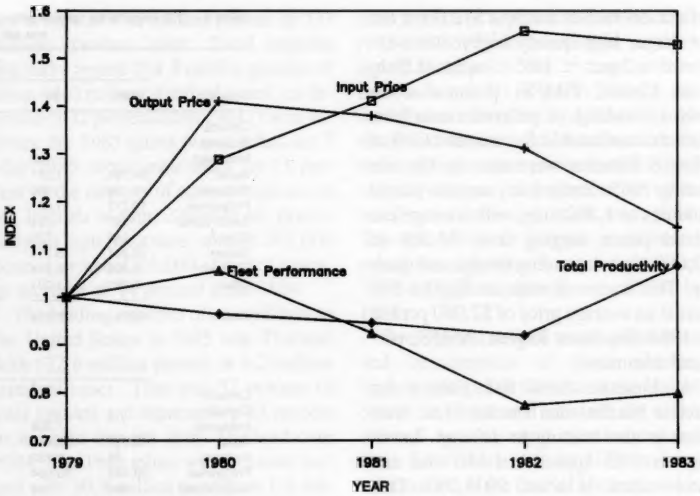


Figure 1.—Economic indexes for the U.S. tropical tuna purse seine fleet, 1979-83.

We computed the aggregate input price index using the same procedure as that for the aggregate output price index, that is, the ratio of the input prices in the year "t" to the input prices in the base year 1979 weighted by the relative contribution of the expenditure on each input in year "t" to total input expenditures. In this case, the inputs considered are labor, capital, fuel, and other intermediate inputs. Unit prices for these inputs over the period 1979-83 were estimated based on purse seine expenditure data reported by the U.S. International Trade Commission (ITC, 1984), data from the Inter-American Tropical Tuna Commission on days absent from port for the U.S. purse seine fleet, and annual average fuel prices from the American Tuna Boat Association (ATA, V. Bernadino, personal commun.).

The unit price of labor, cost per crew day absent, was estimated by dividing the sum of the ITC's reported annual per vessel expenditures on crew and galley by a measure of annual crew days absent per vessel. Annual crew days absent for U.S. purse seiners were derived by multiplying estimated total days absent per vessel by 19 crew members which is the assumed average crew complement in each year of the period.

The sum of the annual interest expense and reported depreciation per vessel from the ITC sample was used as the unit price of capital services in constructing the aggregate input price index.

Other intermediate inputs consist of transshipment services, repairs, gear, insurance, helicopter services, travel, and other. The sum of the nominal expenditures on these inputs per vessel was deflated by the producer price index for industrial commodities to represent the collective use of these inputs in real terms. The nominal expenditure for this category of inputs divided by the corresponding deflated expenditure is used as a proxy for the unit price for other intermediate inputs.

The weights used in calculating the aggregate input price index are the expenditures on each input category relative to the total expenditures on inputs. These weights are derived from the ITC expenditure data and are presented in Table 9 along with the price data used in constructing the aggregate input price index. The aggregate input price index is shown in Figure 1.

Changes in factor productivity, output per unit input, are accounted for through a total factor productivity index which is simply the ratio of an aggregate output index to an aggregate input index. The aggregate indexes of outputs and inputs are formed from Tornqvist-Theil (T-T) quantity indexes for each output produced and input used[14].

Annual output consists of the volume of domestically caught skipjack and yellowfin tuna delivered to U.S. canneries over the 1979-83 period. The number of purse seine vessels comprising the U.S. fleet in each of the years 1979-83 is used as a measure of capital stock. Aggregate labor usage is measured in crew days absent as described above. An estimate of annual fuel consumption by the fleet is obtained by dividing annual fuel expenditure per vessel from the ITC sample by average fuel prices provided by the ATA. Fuel consumption per vessel is then multiplied by the number of vessels in the fleet to get total fuel consumption. The quantity of other intermediate inputs used annually is approximated by deflating the nominal expenditure on this category of inputs by the producer price index for industrial commodities to obtain relative use in constant 1967 dollars. The quantity data used to construct the total factor productivity index is shown in Table 9

[14]For a discussion of the properties of such a total factor productivity index see Christensen (1975). An application of this type of total factor productivity index is given in Ball (1985).

Table 9.—U.S. purse seine fleet economic indexes, 1979-83.

Item and year	Quantity (tons)	Unit price	Revenue ($1,000)	Revenue share	T-T index
Outputs					
Skipjack tuna					
1979	96,582	728.00	70,312	0.36	1.0000
1980	116,085	1,063.00	123,398	0.46	1.0783
1981	98,122	1,030.00	101,066	0.40	1.0060
1982	101,837	965.00	98,273	0.42	1.0209
1983	155,118	799.00	123,939	0.50	1.2260
Yellowfin tuna					
1979	146,336	863.00	126,288	0.64	1.0000
1980	120,555	1,180.00	142,255	0.54	0.8920
1981	127,253	1,170.00	148,886	0.60	0.9170
1982	122,132	1,123.00	137,154	0.58	0.8956
1983	120,634	1,032.00	124,494	0.50	0.8958

Item and year	Quantity	Unit price	Expense ($1,000)	Expense share	T-T index
Inputs					
Capital (number of vessels)					
1979	125	336,000	42,000	0.20	1.0000
1980	122	440,000	53,680	0.19	0.9953
1981	119	625,000	74,375	0.25	0.9890
1982	121	780,000	94,380	0.28	0.9922
1983	108	725,000	78,300	0.28	0.9655
Labor (number of crew days absent)					
1979	575,206	114.0896	65,625	0.32	1.0000
1980	561,241	161.7273	90,768	0.33	0.9920
1981	565,003	143.0099	80,801	0.27	0.9947
1982	569,791	133.7859	76,230	0.23	0.9974
1983	460,940	139.4108	64,260	0.23	0.9409
Fuel (1,000's of gallons annually)					
1979	46,004	0.6820	31,375	0.15	1.0000
1980	60,783	0.8430	51,240	0.18	1.0470
1981	69,006	0.8450	58,310	0.20	1.0735
1982	78,354	0.8200	64,251	0.19	1.0948
1983	62,671	0.8220	51,516	0.18	1.0523
Other intermediate inputs (1967 dollars)					
1979	28,750	2.3652	68,000	0.33	1.0000
1980	30,256	2.7500	83,204	0.30	1.0162
1981	27,608	3.0431	84,014	0.28	0.9877
1982	33,275	3.1273	104,060	0.31	1.0479
1983	28,080	3.1615	88,776	0.32	0.9924

Item and year	Aggregate output price index	Aggregate output index	Aggregate input price index	Aggregate input index	Total factor prod. index	Fleet % index
Indexes						
1979	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1980	1.4100	0.9733	1.2879	1.0096	0.9640	1.0554
1981	1.3794	0.9561	1.4115	1.0066	0.9454	0.9239
1982	1.3115	0.9462	1.3580	1.0293	0.9192	0.7737
1983	1.1467	1.0479	1.5299	0.9830	1.0660	0.7990

Sources: Statistics and Market News, Southwest Region, NMFS, NOAA; U.S. International Trade Commission; Inter-American Tropical Tuna Commission.

together with the T-T indexes and the aggregate output and input indexes. The total factor productivity index is displayed in Figure 1.

By combining the aggregate output price index (*OPI*), the aggregate input price index (*IPI*), and the total factor productivity index (*TFPI*), a composite fleet performance index (*FPI*) for year "*t*" can be written as:

$$FPI_t = OPI_t * TFPI_t/IPI_t,$$

where the terms to the right of the equal sign are those indexes defined above. The *FPI* is an expression of the economic performance of the fleet in year "*t*" relative to the baseline year, 1979. Because the *FPI* is an aggregation of ratios of output prices, input prices, cannery deliveries, and input usage, it reflects the effect of a change in any of these factors throughout the period 1979-83. Any increase in the aggregate output price index or the total factor productivity index, or both, relative to the aggregate input price index, will register an improvement in fleet economic performance. Likewise, the *FPI* will decline given a rise in input prices relative to a decrease in output prices, vessel productivity, or both. The *FPI* shown in Figure 1 denotes the collective effect of changes in revenues, costs, and fleet productivity on fleet performance over the 1979-83 period.

Based on projections using the purse seine cost-earnings data from the 1984 ITC investigation, we found that the U.S. fleet experienced a net accounting loss in 1979, which is the base year used in calculating the fleet economic indexes. Therefore, when interpreting subsequent values of the *FPI*, one should keep in mind that a value greater than one in year "*t*" does not necessarily mean that the fleet realized a profit in that year. It means that it improved its economic performance relative to the base year—that is, the fleet could be earning a profit in "*t*"; the fleet could be just breaking even in year "*t*"; or the fleet is continuing to operate at a loss in year "*t*," although the loss will not be as great as in the base year. On the other hand, if the index in "*t*" is less than one, the fleet is performing worse than it did in the base year. Also, the indices are calculated for the fleet and therefore will not necessarily reflect the performance of an individual vessel. When a poorly performing vessel leaves the fleet, fleet performance may be enhanced due to an improvement in overall productivity.

Through 1980, the *FPI* improved due to a significant increase in the aggregate unit output price index which exceeded a substantial increase in the aggregate unit input price index and a slight decline in total factor productivity index. A decline in the aggregate output price index relative to an increase in the aggregate unit input price index and little change in the total factor productivity index led to a drop in the *FPI* for 1981. The *FPI* decreased further during 1982 as the output price and total factor productivity indices moved downward while the input price index continued to rise. Due to a substantial decrease in the size of the fleet and a significant increase in tropical tuna cannery deliveries, the total productivity index increased sharply

in 1983. Because this was accompanied by a slight decline in the aggregate input price index, the *FPI* rose despite a further decline in the aggregate output price index.

The changes in the indices over the 1979-83 period are not unexpected, given the developments in international supply and expansion of the fishery into more productive grounds. Ex-vessel prices have been depressed as the supply of raw tuna has increased, and at the same time input prices have continued to climb, which compels individual vessels to improve productivity to maintain overall performance. On a fleetwide basis, this is reflected in the total factor productivity index for 1983, the year in which there was a major push by the U.S. fleet into the western Pacific.

Acknowledgments

The authors wish to express their appreciation to the U.S. tuna industry for its continuing support. Their assistance through voluntary reporting of data made this report possible.

Literature Cited

Ball, E. V. 1985. Output, input, and productivity measurement in U.S. agriculture, 1948-79. Am. J. Agric. Econ. 67(3):475-86.

Christensen, L. R. 1975. Concepts and measurement of agricultural productivity. Am. J. Agric. Econ. 57(5):910-15.

Norton, V. J., M. M. Miller, and E. Kenny. 1985. Indexing the economic health of the U.S. fishing industry's harvesting sector U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/NEC-40.

U.S. DOC. 1984. Operation price watch. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, National Fishery Statistics Program, Monthly Reports, 17 p.

———. 1985. Operation price watch. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Natl. Fish. Stat. Program, Monthly Rep., 17 pp.

ITC. 1984. Certain canned tuna fish: Report to the President on investigation no. TA20153 under section 201 of the Trade Act of 1974. U.S. Int. Trade Commiss., 54 p.

U.S. and South Pacific Island States Sign Regional Fisheries Treaty

On 2 April 1987, representatives of the United States and Pacific Island States signed a 5-year regional fisheries treaty in Port Moresby, Papua New Guinea. The Pacific Island States which signed the agreement were: Australia, the Cook Islands, the Federated States of Micronesia, Fiji, Kiribati, the Marshall Islands, Nauru, New Zealand, Niue, Palau, Papua New Guinea, the Solomon Islands, Tuvalu, Vanuatu and Western Samoa. The treaty sets forth the terms and conditions which will apply to fishing by U.S. vessels in the region. The treaty will enter into force after ratification by the United States and ten of the signatory Pacific Island States. Three of these ten must be Papua New Guinea, Kiribati, and the Federated States of Micronesia.

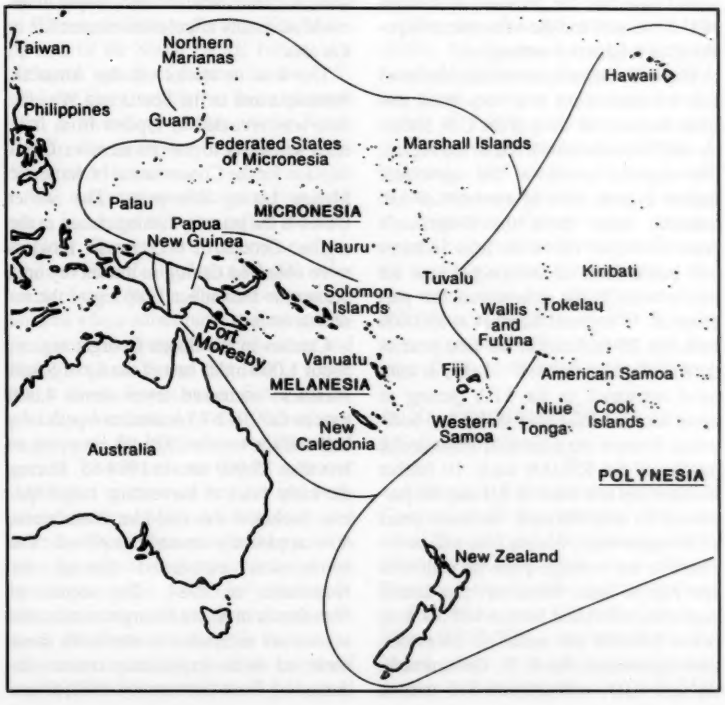
Regional Licenses

Under this treaty, the U.S. tuna industry will purchase annual regional licenses issued by the South Pacific Forum Fisheries Agency (FFA). During the first year, the industry has guaranteed the purchase of at least $1.75 million worth of licenses (35 licenses at $50,000 per vessel). In addition, $250,000 in annual technical assistance from the U.S. industry—the most advanced in the world—will help the Island States develop their own fishing industries. In many instances, fisheries are the principal natural resource available for development by the Island States.

Associated with the treaty is an agreement between the Agency for International Development (AID) and the FFA which provides an annual assistance package of $10 million to the Pacific Island States for 5 years. Of this assistance, $9 million will be in the form of a cash transfer, while $1 million will be in the form of AID development projects. The treaty is the product of over 2 years of intensive negotiations which began in September 1984 in an effort to resolve the access problems encountered by U.S.-flag tuna vessels fishing in the region. The successful conclusion of the treaty is in the best spirit of the long tradition of close and productive relations between the U.S. and the Pacific Island States.

Background

During the past several years, the U.S. tuna fleet has been fishing extensively in the Western Pacific Ocean. This region has now become a significant fishing area for the tuna fleet, though its traditional fishing grounds in the Eastern Pacific remain important as well. The United States neither claims nor recognizes jurisdiction over highly migratory species of tuna beyond 12 n.mi. from the coast. This position is mandated by the Magnuson Fishery Conservation and Management Act and was endorsed by the Presidential Proclamation of 10 March 1983, establishing an Exclusive Economic Zone. However, all Pacific Island States claim jurisdiction over tuna to 200 n.mi. from their coasts. This jurisdictional dispute has resulted in the seizure of two U.S. tuna vessels in the Western Pacific in recent years: the *Danica* in 1982 by Papua New Guinea and the *Jeanette Diana* in 1984 by the Solomon Islands. Both incidents triggered retaliatory embargoes by the United States, as man-



dated by the Magnuson Act, on imports of tuna products from the seizing nations.

Negotiations

To resolve these problems, the United States began to negotiate a regional licensing agreement with 16 Pacific Island States. After the negotiations began, the region took on increased importance when the Soviet Union successfully negotiated a fisheries access agreement with the island nation of Kiribati and began to make overtures to other countries in the region. The agreement with Kiribati lapsed after 1 year. However, the Soviet Union recently concluded a 1-year agreement with Vanuatu. The treaty provides the Island States with an alternative to dealing with the Soviet Union on fisheries. The treaty sets out terms and conditions under which U.S.-flag fishing vessels will be able to purchase regional licenses to gain access to some 10 million square miles of rich fishing waters in the South Pacific Ocean which are within the 200-mile Exclusive Economic Zones of the Island States. Such an agreement would eliminate the prospect of seizures of U.S. vessels and the subsequent imposition of retaliatory embargoes.

The U.S. Department of State believes that the agreement is a very good one from the point of view of the U.S. industry and fishermen involved in the region. The regional nature of the agreement makes a great deal of operational and practical sense from the fisherman's point of view. The U.S. tuna industry will pay at least $2 million per year for this access. It has guaranteed the purchase of 35 regional licenses at $50,000 each ($1.75 million) in the first year of the treaty, plus provide $250,000 in technical assistance to the FFA (acting as agent for the Island States). Up to 5 additional licenses (to a total of 40) may be purchased for $50,000 each; 10 further licenses (up to a total of 50) may be purchased for $60,000 each. In future years of the agreement, license fees will be indexed to the average price of yellowfin and bigeye tuna. However, the annual cost of an individual license will not drop below $50,000 per vessel. In an associated agreement, the U.S. Government, through AID, will provide $10 million annually for 5 years, in economic support to the Island States.

Federal Assistance

The U.S. Government assistance, called for by the agreement, responds to the long-standing U.S. commitment to assist the economic development of these democratic, pro-western Island States. The treaty will come into force when ratified by the United States and 10 Pacific Island States. Parties to the treaty are: Australia, the Cook Islands, the Federated States of Micronesia, Fiji, Kiribati, the Marshall Islands, Nauru, New Zealand, Niue, Palau, Papua New Guinea, the Solomon Islands, Tonga, Tuvalu, Vanuatu, Western Samoa, and the United States. We expect that the treaty will come into force during the summer or fall of 1987. License fees and U.S. Government assistance called for under the treaty and the associated agreement must be paid before the industry may receive licenses. (Source: U.S. Department of State press release and IFR 87/26.)

Antarctic Fish Stocks May Be in Trouble

Heavy commercial fishing in Antarctic waters, primarily by the Soviet Union, may have substantially depleted fish stocks in the region, according to a survey being conducted by the Commerce Department's National Oceanic and Atmospheric Administration (NOAA). William E. Evans, head of NOAA's National Marine Fisheries Service, said substantial decreases in fish populations could adversely affect other marine life in the area.

The loss in stocks off the Antarctic Peninsula and in the Scotia and Waddell seas was revealed in reports from fisheries scientists to the 19-member Commission for the Conservation of Antarctic Marine Living Resources. The Soviet Union is the primary fishing nation in the region. Groups of 6-12 Soviet trawlers were observed fishing in the survey area during the December 1986 leg of the research cruise.

Catches in the South Georgia region, about 1,000 miles east of the tip of South America, increased from about 4,000 tons in the 1972-73 season to a peak of a half-million tons in 1979-80, dropping to less than 75,000 tons in 1984-85. During the early years of harvesting, target species included the cod-like Notothenia, now apparently severely depleted. The commission eliminated fishing for Notothenia in 1984. The stocks of Notothenia in South Georgia waters this season are estimated at one-tenth those observed on an exploratory cruise conducted by West Germany in 1982, Evans said. Analysis is under way by U.S. and Polish scientists to confirm the preliminary findings.

Data from the survey suggest that icefish, a medium-sized, bottom-dwelling species heavily fished in the late 1970's, are depleted or approaching depletion. The survey is being conducted jointly by the NMFS and the Sea Fisheries Institute of Poland, on the Polish vessel *Prof. Siedlecki*. It was currently operating in the vicinity of the Antarctic Peninsula, and had traversed the entire shelf area around South Georgia in the most thorough and extensive survey undertaken to date.

Member nations of the commission include Argentina, Australia, Chile, West Germany, France, East Germany, Japan, Norway, Poland, the USSR, the United Kingdom, and the United States. Evans said, however, that an evaluation made on one seasons's effort must be interpreted "cautiously."

Cape Hatteras Maritime Interpretive Center Eyed

The National Oceanic and Atmospheric Administration (NOAA) is considering a North Carolina proposal to establish a maritime interpretation center at Cape Hatteras, N.C., which would highlight the USS *Monitor* as the most famous shipwreck in the "Graveyard of the Atlantic." Herbert Kaufman, chief of NOAA's Marine and Estuarine Management Division, which administers the USS *Monitor* Project and manages the *Monitor* National Marine Sanctuary off

Cape Hatteras, N.C. said, "The *Monitor*, which was built in New York, fought its most famous battle at Hampton Roads, and sank off Cape Hatteras, is a national treasure. North Carolina's proposal is the kind of participation that we are encouraging among a number of museums and other groups that can play key roles in telling the story of the *Monitor*."

NOAA recently selected the Mariners' Museum of Newport News, Va., to be the principal *Monitor* museum, and recommended that other groups and museums, including the state of North Carolina, participate in the display and interpretation of *Monitor* artifacts. This could include loans of artifacts and the interpretation of specific aspects of the *Monitor* story. Further discussions on the North Carolina initiative will be held between NOAA officials and the Director of the North Carolina Division of Archives and History and the Chairman of the North Carolina Marine Science Council, in conjunction with final arrangement being made with the Mariners' Museum. The Civil War ironclad USS *Monitor*, popularly credited with ending the era of wooden warships, sank in 230 feet of water 16 miles off Cape Hatteras on New Year's Eve in 1862 while under tow during a raging storm. It fought its most famous battle at Hampton Roads with the Confederate ironclad *Virginia* (formerly the *Merrimack*) on 9 March 1862.

Albacore Studied by NMFS, New Zealand, and French Scientists

The NOAA ship *Townsend Cromwell* completed 2 months of fish stock surveys in the South Pacific in March, gathering information on albacore, *Thunnus alalunga*, crab, shrimp, and bottomfish. Reports Jerry A. Wetherall, chief scientist on the albacore survey, the albacore research was a collaborative effort of the *Cromwell*, government research vessels from New Zealand and France (New Caledonia), and U.S. commercial albacore boats. Wetherall is with the Honolulu Laboratory of the NMFS Southwest Fisheries Center. Besides U.S. scientists from Honolulu and the SWFC's laboratory in La Jolla, California, the *Cromwell's* survey crew included biologists from New Zealand, the Cook Islands, and Tonga, Wetherall noted.

A main objective of the albacore research was to describe ocean characteristics in regions where albacore are concentrated near the sea surface and available for harvesting by U.S. trolling vessels. Another was to develop the capability to predict albacore migration routes and seasonal changes in their location.

Albacore are abundant in the South Pacific, but most of the annual catch of 35,000 tons is harvested in subtropical waters at depths of 450-750 feet by tuna longlining fleets from Taiwan, South Korea, and Japan. Only a few thousand tons are caught near the surface, mostly by small New Zealand trollers fishing near their home islands. In January 1986, two U.S. trollers ventured into the South Pacific for the first time, and made excellent catches at the surface in an area about 1,200 miles south of Tahiti. The boats returned to the same location this year, joined by five other trollers, and are again making phenomenal catches of up to 10 tons of albacore per day. The development of the South Pacific fishery is a welcome upturn of fortune for the U.S. albacore fleet, which has been plagued with a dwindling market in the North Pacific due to cannery closings in California and Hawaii.

The cooperative albacore survey took place in a band of water called the Subtropical Convergence extending from Chile to New Zealand about 2,400 miles south of the Equator. The Convergence is an area where subtropical and subantarctic waters blend together. Fishermen and biologists have found that this is where many kinds of open-ocean fishes are especially abundant. At over 100 locations in this zone the research vessels lowered special instruments to depths of over 3,000 feet to measure vertical and horizontal changes in ocean temperature and salinity. This information will be used to describe physical characteristics of the convergence and particularly the areas near the ocean surface considered optimum for albacore trolling. In these areas albacore concentrate to feed on small mackerel and other animals such as squid and amphipods.

The research ships and the commercial boats also caught, tagged, and released alive several hundred albacore. It is hoped these fish will be caught again by U.S. fishermen, South Pacific islanders or Asian tuna longliners. A reward will be offered for return of the tagged fish. Recapture information will provide insights on South Pacific albacore migration habits, about which nothing is known. Such knowledge is vital for locating the best fishing grounds and seasons and for developing the scientific basis for international conservation of the albacore stock.

In addition to the oceanographic mapping and albacore tagging, the research vessels collected biological material for estimating the ages and growth rate of albacore and determining their geographical origins, maturity, fat levels, and food habits. Data collected during the surveys and commercial fishing operations will be shared among researchers and fishing interests in the participating countries and used as a basis for rational fishery development and assessment of optimum catch levels.

After the albacore survey was concluded, the *Cromwell* visited waters off Niue and American Samoa, where bottom depth contours were charted and a variety of fishing gear was used to sample deep slope resources. Jeffrey J. Polovina, chief scientist for this portion of the cruise, reports that several species of deepwater shrimps were trapped around both Niue and American Samoa, but preliminary catch rates suggest that this resource is less abundant in these areas than in Hawaiian waters. Nautilus were also obtained in shrimp and fish traps deployed around American Samoa.

U.S., France to Study Mid-Atlantic Ridge

Anthony J. Calio, Under Secretary of Commerce and Administrator of the National Oceanic and Atmospheric Administration (NOAA), and Yves Sillard, Director-General of the Institut Francais de Recherche pour l'Exploitation de la Mer (IFREMER), announced in late March plans to conduct joint oceanographic investigations on the Mid-

Atlantic Ridge in 1990-92. Several U.S. and French agencies will participate in the multi-disciplinary project, which will focus on the structure, dynamics, and composition of the deep-sea floor, the circulation and dispersion of hydrothermal fluids, the related biological communities, and the presence of metalliferous deposits on the Mid-Atlantic Ridge. The project is a continuation of work by the two countries on the East Pacific Rise.

A joint U.S.-France task group will provide scientific recommendations and an organizational plan for a research program, including possibilities for research by scientists from other countries, by 1988. The project will include several months of operation at sea using surface ships and submersibles.

Turtle Saving Rules for Shrimp Boats Are Phased in This Year

The Commerce Department issued regulations in June requiring shrimp fishermen in the Gulf of Mexico and parts of the Atlantic Ocean to begin reducing the number of sea turtles caught inadvertently in their nets. The regulations, culminating a series of discussions and public hearings with environmental groups and shrimp fishing organizations that began last fall, will become effective beginning, in some cases, in October 1987. They will require some shrimp boats to install turtle excluder devices, known as TED's, in their nets. The TED is designed to allow turtles to escape from trawl nets while the nets still retain the shrimp.

The Commerce Department's National Oceanic and Atmospheric Administration (NOAA) estimates that almost 48,000 turtles are caught each year in shrimp nets and more than 11,000 of them drown. Sea turtles, whose populations have fallen substantially in recent years, are protected by Federal law. NOAA said it expects these new regulations to reduce significantly the accidental killing of all five endangered and threatened sea turtles—the loggerhead, Kemp's ridley, green, leatherback, and hawksbill—found from Texas to North Carolina. The regulations will not require TED's to be carried by shrimp boats of less than 25 feet fishing in offshore waters or shrimp boats of any length fishing in inshore waters, provided they limit the time they tow their nets to 90 minutes. There will be no tow-time restrictions for these boats if they install TED's.

Starting 1 October, shrimp boats 25 feet and longer fishing offshore in the Canaveral, Fla., area must use TED's. The TED requirement for other offshore boats 25 feet and longer will be phased in during 1988. Beginning 1 January, boats in the southwest Florida area will have to carry TED's when they are within 15 miles of shore. From March through November, shrimpers in the Gulf will be required to use TED's within 15 miles of shore. Shrimp boats in all Atlantic waters must use TED's from May through August. Copies of the regulations can be obtained from either Charles Karnella, National Marine Fisheries Service, Room 805, 1825 Connecticut Ave., N.W., Washington, DC 20235, or from Charles Oravetz, NMFS, 9450 Koger Blvd., St. Petersburg, FL 33702 (telephone 813-893-3366).

Sea Turtle Reports Are Ruled for Texas Closure

Owners or operators of shrimp trawlers must report any incidental taking of endangered or threatened sea turtles in Federal waters outside the closed area off Texas according to Craig R. O'Connor, Acting Regional Director of the National Marine Fisheries Service (NMFS). The requirements for reporting incidentally caught sea turtles were published in the Federal Register on 21 May 1987, but were not in effect until approved by the Office of Management and Budget. That approval was published on 8 June.

Federal waters from 9 to 15 n.mi. offshore from Texas were closed on 1 June to coincide with the closure by Texas of its offshore waters. The closure is scheduled to remain in effect through 15 July. During this period, the owner or operator of a shrimp trawler that incidentally takes any sea turtle must report the following information within 24 hours after landing: The vessel's name, the species of turtle caught, the date and location where caught, whether alive or dead when released, whether or not the turtle was tagged, the tag number, if any, and the approximate tow time. Sea turtle identification guides and cards for submitting reports may be obtained from and reports must be submitted to: Director, NMFS Laboratory, 4700 Avenue U, Galveston, TX 77550.

Alleged Turtle Killing Under Investigation

On 23 July 1987, Federal agents from the National Marine Fisheries Service and officers of the Florida Marine Patrol jointly investigated an alleged butchering of a 250-pound loggerhead sea turtle in Sugarloaf Key, Fla. Loggerhead sea turtles are listed as a threatened species under the Endangered Species Act of 1973, 16 U.S.C. 1531 et seq., and regulations promulgated thereunder at 50 C.F.R. Part 227.

As a result of the investigation, Raymond E. Martinez and Suzanne S. Fernandez, both of Monroe County, Fla., were arrested on Saturday, 25 July 1987, on Federal warrants. Martinez and Fernandez appeared before U.S. Magistrate Hugh Morgan. They were each released on $50,000 personal surety bonds. The information charges the defendants with conspiracy in the unlawful taking and possession of a threatened marine reptile that is a loggerhead sea turtle. A criminal conviction on these charges could result in fines up to $10,000 and/or 6 months incarceration per count.

Two persons who fled the scene of the alleged crime were being actively sought for questioning. Anyone having information regarding the whereabouts of these two people should contact the National Marine Fisheries Service at 305-294-7444 or the Florida Marine Patrol at 305-743-6542. A trial date had not yet been set.

Monk Seals Moved to Hawaii's Kure Atoll

Three 1-year-old Hawaiian monk seals were moved to Kure Atoll in early April as part of the National Marine Fisheries Service (NMFS) program to rebuild that seal population, reports Richard S. Shomura, Director of the NMFS South-

west Fisheries Center's Honolulu Laboratory. "These three females were rescued last summer as underdeveloped pups at French Frigate Shoals," Shomura reported. They were brought to Honolulu on chartered flights paid for by the Center for Environmental Education, a national nonprofit organization dedicated to protecting marine wildlife and their habitat.

William G. Gilmartin, Leader of the Honolulu Laboratory's Marine Mammals and Endangered Species Program, said "All three of the pups were initially taken to our Kewalo Research Facility where, with the assistance of a few volunteers, they were hand fed once or twice daily for several weeks before they began feeding on their own." Two of the pups were then transferred to the Waikiki Aquarium where they were cared for until about February, when they were returned to Kewalo Basin. "Monday morning the three were given their last meal of dead fish, and early Tuesday they were taken to the Coast Guard Station at Barbers Point for the 5-hour flight to Kure and their first live reef-fish meal," Gilmartin said. At Kure, with the assistance of Coast Guard Loran Station personnel, they were carried from the plane to a large fenced enclosure on the beach. "They will only be kept in this pen about a month," according to Gilmartin, "until they demonstrate they can catch sufficient live food on their own to support themselves. The enclosure is kept stocked with fish trapped in the lagoon there, so they learn to feed on the same species they will find when they are released." He added that "This technique has proven successful the last 2 years, 1985 and 1986, with five animals rehabilitated and relocated in the same manner: All are still alive and appear healthy." And, Gilmartin said "This effort is critical to recovery of the Kure monk seal population, since the number of births at Kure in recent years has been very low; last year only a single male pup was born. We are adding more females to Kure with this relocation work than are being born at Kure."

According to Shomura, "A very significant milestone was reached at the end of March at Kure when one of the first females reared in the pup 'Head Start' project gave birth. This work, started in 1981, involves collection of all female pups at Kure after they are weaned. They are kept in this beach enclosure during the critical 2-5 months between weaning and the end of the summer, to protect them from sharks and aggressive adult male seals." The pups are flipper tagged before release and Gilmartin said, "That is how we are able to follow them year to year, and monitor survival, movement, and reproductive patterns. That tag information is how we knew that one of the 1981 pups gave birth this year." He said "The only other information available to us on age at first birth in the monk seal was a single animal known to have a pup at 7 years, but even at 6 years, this is a late maturing species, compared with other seals."

Gilmartin added that "Since the Head Start project was started at Kure in 1981, 13 Kure-born female pups have spent their first summer in the enclosure, and since 1985 eight female yearlings, relocated from French Frigate Shoals, have learned to feed in the enclosure before release at Kure. Of these 21 seals, only 1 has disappeared." Gilmartin emphasized the importance of this recent birth as the real measure of success: Getting more breeding females into the Kure monk seal population. And, he said "Everyone who has helped us with this recovery work over the last 6 years deserves some credit for this success, including the U.S. Fish and Wildlife Service, Center for Environmental Education, the U.S. Coast Guard, State of Hawaii, Waikiki Aquarium, and the many volunteers who have assisted with the collection and captive care and feeding of the young seals."

Hawaiian Research Eyes Pelagic Armorhead, Seals

A 45-day research cruise by the NOAA ship *Townsend Cromwell*, which ended 14 May 1987, conducted fisheries research in the vicinity of the Hancock Seamounts, Northwestern Hawaiian Islands, and off leeward Oahu, reports Richard S. Shomura, Director of the NMFS Southwest Fisheries Center's Honolulu Laboratory. The cruise consisted of two parts; the first was 38 days and involved primarily the collection of biological and oceanographic data from the Hancock Seamounts and adjacent waters. Secondary missions, according to Shomura, involved the establishment of a scientific field camp at Laysan Island in the Northwestern Hawaiian Islands for studies of the Hawaiian monk seal and other wildlife, and the transport of five adult monk seals from Laysan Island to Honolulu. The last 7 days involved sea trials of new sampling gear for juvenile fishes and invertebrates.

Robert L. Humphreys, Jr., Chief Scientist of the first part of the cruise, reported that fishing operations were conducted at the Hancock Seamounts to assess the relative abundance of pelagic armorhead and other commercially valuable fishes. These operations provide information for monitoring the recovery of these previously depleted fish stocks and also provided specimens for biological studies. The pelagic armorhead was the target of a Soviet and Japanese trawl fishery at these and other northern seamounts and were intensively fished during 1968-76. In 1977, U.S. implementation of the 200-mile Fishery Conservation Zone brought the Hancock Seamounts under U.S. jurisdiction. Limited foreign fishing, by permit only, occurred at the Hancock Seamounts during 1978-84, and by 1985 these seamounts were closed to all foreign fishing. Preliminary results from this and other recent cruises indicate that the armorhead resource at the Hancock Seamounts is slowly recovering.

During Leg I, current meter moorings were successfully deployed and retrieved for the first time from the summit and upper slopes of the Hancock Seamounts. Results should provide insight on the possible relationship between seamount oceanography, fish distribution, and food availability at the Hancock Seamounts.

The relocation of the five adult monk seals from Laysan Island to Honolulu is part of an investigation being conducted by Honolulu Laboratory personnel into incidences of "mobbing" behavior at Laysan Island involving the injury and death of female Hawaiian monk seals. All five adult monk seals removed from Laysan Island were aggressive males previously involved in such incidents. These

monk seals are currently being maintained at the Kewalo Research Facility of the Honolulu Laboratory.

The second leg of the cruise was conducted off Kahe Point, Oahu, and involved sea trials on three new types of gears for collecting juvenile fishes and invertebrates. Bert S. Kikkawa, Chief Scientist, reported that the new sampling tools included a fine mesh midwater rope trawl, a large surface or neuston trawl, and plastic light traps. These new tools will be used in the future to assess species diversity and distribution patterns of juvenile fishes and invertebrates for island recruitment, age, and growth studies.

Japanese Request to Take Seals and Porpoises Cut

The Commerce Department substantially reduced in May 1987 Japan's requested annual quota of certain marine mammals that could be killed during fishing operations in the 200-mile U.S. fishery conservation zone in the North Pacific Ocean and Bering Sea. The new Federal permit, which went into effect on 10 June, allows the salmon fishermen to take 6,039 Dall's porpoises over the next 3 years, but does not allow taking of seals or sea lions. The permit further set a limit of 2,942 porpoises that can be taken in any one year.

In July 1986, the Japanese, through a salmon fishing association, requested a 5-year permit that would have set an annual quota of 5,500 porpoises, 450 northern fur seals and 25 Steller sea lions caught accidentally during the salmon harvest. The marine mammals can become entangled, and frequently injured or drowned, in the nylon gillnets used by the Japanese fishermen. The ruling follows extensive hearings held late last year in Seattle, Wash., in which more than a dozen animal rights and environmental organizations and other groups, including the Japanese salmon fishing association, participated.

The administrative law judge in charge of the hearings had recommended a 5-year permit that would allow 1,750 porpoises and 45 northern fur seals to be killed or injured in 1987. The porpoise quota would have been reduced 5 percent each year for the next 4 years. The Commerce Department's National Oceanic and Atmospheric Administration (NOAA) said the judge's recommendation would have allowed just under 5,000 porpoises and 135 fur seals to be taken in the first 3 years. But, NOAA added, the judge failed to provide a quota for taking Dall's porpoise from the Bering Sea population, even though he found the stock to be healthy.

NOAA's total quota is slightly higher than the judge's recommendation, the agency said, because it reflects the addition of the Bering Sea population. NOAA estimates the present population of Dall's porpoise in the western North Pacific to be just over 692,800, and in the Bering Sea to be about 216,000. NOAA was unable to determine if the Soviet stock of fur seals was depleted, although the agency does consider the stock of fur seals off Alaska's Pribilof Islands depleted. As a result, NOAA said, no incidental take of either stock will be allowed.

Mexican Fishing Vessels Seized, Fined, Released

On 20 March, 1987, U.S. Coast Guard personnel from the cutter *Pt. Baker* and from the Coast Guard Station at Port Isabel, Tex., intercepted and seized two Mexican shark boats fishing illegally in the U.S. exclusive economic zone off Port Isabel, announced Craig O'Connor, Acting Regional Director, NMFS Southeast Regional Office. The two seized boats, 25- to 26-foot fiberglass open-cockpit crafts powered by 48-55 horsepower outboards, were fishing between 5 and 10 n.mi. north of the U.S.-Mexican border about 27 miles offshore. Both vessels made a run for the border before being apprehended. The vessels were part of a larger pack of vessels that had been observed fishing north of the border on 19 and 20 March by USCG air and sea units.

NMFS dispatched Special Agent Robert Williams to Port Isabel on 20 March to assume custody of the vessels, gear, and catch and to assist the Coast Guard boarding personnel with statements and case preparation activities. Notices of Violation and Assessment were transmitted to Special Agent Williams on 25 March 1987 for service upon the owners/operators of the seized boats. The owners/operators of these boats were involved in an October 1986 incident when they were assessed and paid penalties of $500 each for the return of their vessels. On Friday, 27 March 1987, Martin Hernandez and Higinio Gomez Mendoza settled their cases with the government by paying penalties of $1,500 each, in addition to forfeiting their gear and fish. This is three times the settlement amount paid in October 1986.

Then, on 8 April 1987, U.S. Coast Guard personnel from the cutter *Pt. Nowell* and the Coast Guard Station at Port Isabel, Tex., intercepted and seized four more Mexican shark boats fishing illegally in the U.S. exclusive economic zone (EEZ) off Port Isabel, O'Connor reported. The U.S. Coast Guard had received complaints that Mexican shark boats were fishing in the U.S. EEZ. A Coast Guard helicopter, a 41-foot Coast Guard patrol boat, and the *Pt. Nowell* were dispatched to detect and intercept these vessels. The Coast Guard helicopter documented fishing activity by several Mexican vessels. The 41-foot patrol boat intercepted and seized three Mexican vessels before they cou'd leave the U.S. EEZ. The *Pt. Nowell* intercepted and seized a fourth Mexican shark boat in the U.S. EEZ. The four vessels, 28- to 30-foot fiberglass open-cockpit crafts, were powered by 48-55 horsepower outboards.

NMFS dispatched two Special Agents to Port Isabel to assume custody of the vessels and gear. Special Agent Joseph Noone served the owners and operators (Respondents) of the four Mexican vessels with Notices of Violation and Assessment. The cases were settled between the Government and Respondents on Tuesday, 28 April 1987. The Respondents paid $500 for each of the four violations, and forfeited the gear onboard the vessels. Additionally, the owners of the vessels agreed to relinquish and transfer to the U.S. Government the right, title, and interest in their vessels if they are observed violating the Magnuson Act again within 2 years.

United States-Spain Fisheries Trade, 1980-85

Introduction

The U.S. fishing industry's hopes to enter the $500 million Spanish seafood market have not materialized, even though Spain was forced to become a net importer of fishery products in 1977, due to the extension of 200-mile Exclusive Economic Zones (EEZ) by coastal countries. U.S. exports of edible seafoods to Spain have declined to only $3.5 million in 1980 to only $0.2 million in 1985 (Fig. 1) At the same time, Spain has increased its exports to the United States from $20 million in 1980 to $38 million in 1985. Important U.S. fishery products exported to Spain in 1985 included frozen squid, Pacific salmon, and salted cod. Spanish exports to the United States during 1985 included significant amounts of fresh or frozen tuna, swordfish, and shellfish.

Spain's 1 January 1986, accession to the European Community (EC) has begun to change Spain's highly structured system of import regulations. It is difficult to anticipate the immediate impact of Spanish entry into the EC on U.S.-Spain trade in fishery products, as tariffs and quantitative restrictions on certain commodities will not be fully modified for another 7-10 years. The United States and the EC are currently discussing EC trade policies under Article XXIV of the General Agreement on Tariffs and Trade (GATT). These GATT meetings will serve to clarify both the U.S. and EC positions on fish trade.

The Spanish Seafood Market

The Spanish market for seafood products is highly developed, and Spanish consumers are known for their high standards and good taste in choosing quality seafoods. Spaniards consume more than twice the seafood eaten by the average EC citizen, who consumes 15 kg per year. Spain's domestic market for edible fishery products, one of the largest in Europe, is estimated to be worth about $500 million.

Spaniards consumed more than 1.2 million metric tons (t) of seafood products during 1985. About 25 percent of the total Spanish supply of fishery products was imported. Spanish consumers have traditionally enjoyed eating fish and shellfish; in 1985, Spain ranked eighth worldwide in seafood consumption with 35 kg per person. Of this amount, fresh fish and shellfish accounted for 70 percent; frozen, 25 percent; and canned/preserved, 5 percent.

Nearly half of the seafood consumed in Spain consists of pelagic species landed by the Spanish fleet and consumed fresh. Favored species include sardine, anchovy, tuna, and mackerel. Groundfish species make up about 40 percent of seafood consumption. Hake is the favorite species, followed by cod, monkfish, and sole. Shellfish, such as squid and shrimp, are also sought by Spanish consumers. Although fresh fish is the traditional consumer preference, frozen fish is slowly gaining acceptance and the shift toward frozen products has accelerated in recent years. Nearly 20 percent of all seafood now sold in Spain in frozen. A significant amount of Spanish seafood imports are in frozen form.

The Spanish Fisheries Trade

The advent of the global extension of fishery jurisdictions to 200 miles in the late 1970's limited Spain's access to traditional distant-water fishing grounds. Lack of access of species favored by the Spanish consumer and the inability of Spanish fishermen to harvest enough fish within their own EEZ has forced Spain to become a net importer of fishery products (Table 1). Because Spain has been unable to remain self sufficient, the Spanish

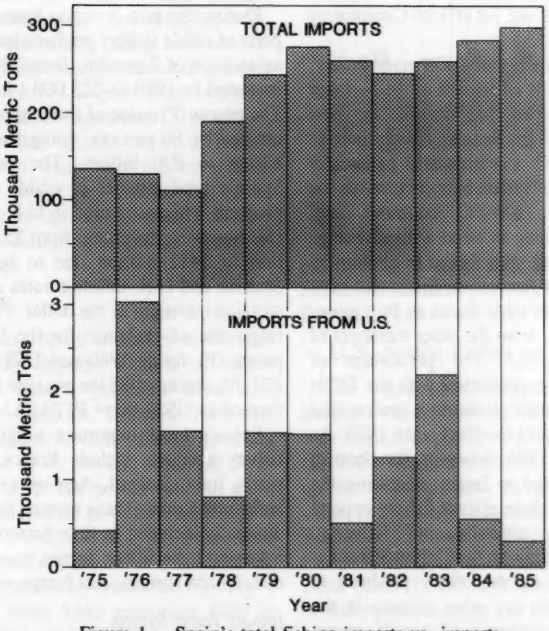


Figure 1.—Spain's total fishing imports vs. imports from the United States, by quantity, 1975-85.

Government has sought access for its large fleet in distant-water fishing grounds.

Spain's important "bilateral trade regime" was developed and adopted during 1977 in response to the changing regime of the sea. The objective of this policy was to protect the interests of Spain's powerful fishing fleet and fishermen's organizations. The intent of the policy was to link foreign access to Spain's profitable market with Spain's access to foreign EEZ's. This policy used both tariff and nontariff barriers (licensing, regulations, marketing standards, import quotas) to influence, or entice, other countries into issuing fishing permits to Spanish vessels.

The accession of Spain to the EC is changing Spanish fishery policy, as well as having an apparent impact on EC fisheries policy making. In revamping the then current Common Fisheries Policy (CFP) (which was valid until the end of 1986), an EC proposal to the Council of Ministers linked access to the EC market with EC vessel fishing rights in foreign EEZ's. This new approach, whether influenced directly by Spanish entry or not, was still being discussed at the Council level and was not yet official Community policy.

The EC's Common Fisheries Policy, which governs all aspects of the Member States' fisheries, has become the new "framework" for Spanish fishery policy. Although EC accession will eventually "relax" Spain's trade barriers towards the Community, non-EC countries will clearly continue to be at a disadvantage vis-a-vis trade with Spain. In abiding by the Treaty of Accession, Spain will have to redirect its trade flows to buy more, increasingly, from the other members of the Community. The percentage of Spanish trade conducted with the EC is already substantial due to a preferential trade agreement in effect since 1970. As of 1 March 1986, however, the Spanish were obligated to begin increasing the Community share of their fishery imports by 15 percent, annually, until 31 December 1992. Although the United States exports fewer edible fishery products to Spain than to any other country in the European Community (Table 2), accession is certain to hurt the potential for increased U.S. fishery exports. U.S. products available for export to Spain will be subject to the generally higher EC Common Customs Tariff (CCT, or EC import tariffs applicabgle to non-EC products) once entering the EC and will have to compete with EC products entering Spain with no tariff. Therefore, U.S. products will be less economically viable than those products from EC Member States or countries with EC trade agreements, such as Norway and Iceland.

Table 1.—Spain's fishery catch, imports, and balance of trade, by quantity.

	Quantity (t)			
Year	Catch[1]	Imports	Exports	Balance of trade
1975	1,500,000	170,000		
1976	1,450,000	140,000		
1977	1,400,000	130,000		
1978	1,350,000	200,000		
1979	1,200,000	250,000		
1980	1,250,000	299,400	158,300	−141,100
1981	1,250,000	270,700	257,700	− 13,000
1982	1,350,000	329,500	234,400	− 95,100
1983	1,250,000	268,800	203,800	− 65,000
1984	1,200,000	297,000	209,500	− 88,000
1985		323,300	230,000	− 93,000

[1]Data is rounded off; no data available for 1985.

Imports

During the past 5 years, Spanish imports of edible fishery products increased an average of 7 percent, from 299,500 t imported in 1980 to 323,000 t in 1985. The peseta (P) value of these imports increased by 80 percent, going from P39 billion to P70 billion. The value of Spain's total imports of edible fishery products when measured in U.S. dollars ($), however, decreased from $539 million to $412 million due to both the Spanish and U.S. inflation rates and the sustained strength of the dollar. (The average rate of exchange for the Spanish peseta (P) during 1980 was US$1.00 = P71.70; during 1985 the average rate increased to US$1.00 = P170.04.)

Spain's most important suppliers of fishery products include France, Denmark, Italy, Iceland, Argentina, Chile, and South Korea. These imports have traditionally included fresh or frozen whole hake and hake fillets, frozen tuna, dried cod, frozen shrimp, and frozen squid.

Import Tariff System

Before Spain was obligated to begin gradual harmonization of its tariff regulations with the EC, the Government of Spain utilized various tariff instruments to restrict imports of fishery products. "Ordinary" tariffs, the Internal Compensatory Tax (ICGI), and the Variable Compensatory Levy (VCL) were applied to prevent the importation of products at less than the domestic price for comparable products.

Table 2.—U.S. exports of edible fishery products to member states of the European Community, by quantity, 1980-85.

	U.S. exports (1,000 t)					
Country	1980	1981	1982	1983	1984	1985
U.K.	20.0	21.7	10.5	15.1	14.7	12.5
France	13.6	14.6	14.0	11.0	9.0	8.7
FRG	9.2	6.7	3.8	5.4	3.1	2.7
Netherlands	5.6	4.2	3.8	3.3	2.6	2.7
Belgium-Luxembourg	5.6	3.8	3.0	2.6	2.0	1.5
Greece[1]	4.3	3.7	3.8	0.4	0.1	0.7
Italy	2.3	1.1	4.4	2.2	1.2	1.7
Spain[2]	1.5	0.5	1.3	2.2	0.5	0.3
Denmark	1.2	0.8	1.0	1.3	1.6	2.1
Ireland	0.2	0.3	0.1	0.2	0.2	1.5
Portugal[2]	0.1	2.0	1.9	4.1	3.0	2.2
Total	63.6	57.4	47.6	47.8	38.0	36.6

[1]Greece became a Member State of the EC in January 1981.
[2]Spain and Portugal became Member States of the EC in January 1986.

The "ordinary" tariffs were applied at 4 different official rates, depending on the country of origin of the product in question. Because Spain had a preferential trade agreement with both the EC and the European Free Trade Association (EFTA), there was both a reduced EC and an EFTA rate on fishery imports from those countries. The "GATT rate" applied to imports from signatories of the GATT having trade agreements with Spain, and the "general rate" applied to imports from countries with which Spain had no trade agreement.

In addition to ordinary tariffs, imports were also subject to the ICGI, and the VCL. the ICGI has since been replaced by the EC's Value Added Tax (VAT), a revenue-producing internal sales tax. Imports of certain products were also potentially subject to the nondiscriminatory VCL. The VCL was a variable levy, reviewed, and frequently changed without prior notice by the Government to make sure that certain imported products were not entering the country at a price lower

Table 3.—Spanish fishery products for which quantitative restrictions on imports from non-EC countries may be maintained.

Item	Item
Fish	Fish
	Fillets
Whole, headless, or in pieces	Cod (fresh or chilled)
Cod (fresh or chilled)	Hake (frozen)
Cod (dried)	
Anchovies (fresh or chilled)	Shellfish
Hake (fresh, chilled, or frozen)	Spinous spider crab (fresh)
Blue whiting	Venus clam (fresh or chilled)
Horse mackerel	

Table 4.—U.S. exports of edible fishery products to Spain, by commodity, quantity, and value, 1980-85.

	Quantity (t)						Value (US $1,000)					
Commodity	1980	1981	1982	1983	1984	1985	1980	1981	1982	1983	1984	1985
Fish												
Salmon												
Fresh or frozen	70	62	82	105	146	109	$ 260	$ 246	$ 318	$ 369	$ 521	$380
Canned	2	3	2		2		10	15	7		7	
Other												
Fresh or frozen	706	326	140	65	80	18	1,575	604	280	79	167	18
Dried	54	33	404	84			162	118	645	120		
Roe	4	26	11	2	1	5	49	302	163	44	28	35
Subtotal	836	450	639	256	229	132	2,056	1,285	1,413	612	723	433
Shellfish												
Squid												
Frozen	629	30	616	1,934	321	162	1,335	57	1,103	3,665	484	224
Canned	41						10					
Shrimp												
Frozen		16		12				52		33		
Canned					1	1					3	6
Other	16	7		1	4		80	40		3	30	1
Subtotal	686	53	616	1,947	326	163	1,425	149	1,103	3,701	517	231
Grand total	1,522	503	1,255	2,203	555	295	$3,481	$1,434	$2,516	$4,313	$1,240	$664

than the current domestic price for those products. The list of products affected by the VCL were published in the weekly *Boletin Oficial del Estado* (the Spanish "federal register"). The following species appeared regularly on the VCL list: Cod, squid, tuna, sardines, anchovy, hake, and crustaceans. As is the case for most countries, tariffs were highest on those products which competed with domestic production and lowest on products, such as tuna, which were required by domestic processors.

Spain was obligated on 1 March 1986 to begin harmonization of its import duties and the EC CCT duties, in seven equal installments of 12.5 percent, on 1 January of each year. The CCT will apply in full from 1 January 1993. In addition, the Government of Spain is required to eliminate all countervailing charges on imports of fishery products. Spain will be allowed, however, to maintain quantitative restrictions up to 31 December 1992 on imports of certain fishery products (Table 3). EC reference prices will apply to each of those products once the quantitative restrictions have been abolished. With the accession of Spain, three new species (monkfish, megrim, and pomfret) will be added to those species already covered by the EC price support and market control system (reference and withdrawal prices).

Nontariff Import Controls

Under the bilateral trade regime, the most effective nontariff import control mechanism used was the import license. The Government of Spain reserved the right to grant, deny, or suspend import licenses as it deemed "appropriate." Under this system, import license applications from countries without bilateral agreements with Spain were considered on a case-by-case basis. The Directorate General for Tariff Policy and Imports in the Ministry of Economy and Finance, was responsible for reviewing import license applications, taking into account the requirements of the domestic industry and the level of imports from countries under bilateral agreements. In effect, countries that wanted to export fishery products to Spain were prevented from doing so, unless they were already bound by a bilateral agreement, usually offering catch allocations in return for export opportunities.

Exports

Although Spain continues to increase its fishery imports, exports of edible Spanish fishery products have also steadily increased. Between 1980 and 1985, exports of edible fishery products increased by 45 percent, from 158,300 t to 230,700 t. The peseta value of these exports increased as well, from P24,000 in 1980 to P60,400 in 1985, an increase of 140 percent. The dollar value of these exports, however, increased by only 4 percent, from $340 million in 1980 to $355 million in 1985. The principal destinations for these Spanish products, mostly fresh or frozen tuna, frozen squid, and canned sardines, have included Italy, Portugal, France, and the United States.

Figure 2.—Spanish imports of U.S. fishery products vs. exports of fishery products to the United States by quantity, 1980-85.

U.S.-Spain Fisheries Trade

The value of U.S.-Spain fisheries trade in 1985 totaled almost $40 million, with Spanish exports to the United States (12,000 t valued at $38 million) making up the majority, both by quantity and value, of that trade relationship. U.S. edible exports to Spain reached a low of 295 t valued at $0.7 million during 1985 (Fig. 2 and Table 4). Although Spanish exports of fishery products to the United States have represented a steady 6 percent of Spain's worldwide exports of edible fish-

Table 5.—U.S. imports of edible fishery products from Spain, by commodity, quantity, and value, 1980-85.

Commodity	Quantity (t)						Value (US $1,000)					
	1980	1981	1982	1983	1984	1985	1980	1981	1982	1983	1984	1985
Fish												
Tuna												
Fresh or frozen	5,500	15,886	9,300	2,800	13,000	3,600	4,600	19,516	10,694	2,650	17,900	7,360
Canned	66	77	54	65	103	151	367	402	302	300	394	560
Swordfish												
Fresh						1,275						6,520
Frozen				15		20				36		99
Other												
Fresh or frozen	138	78	112	58	118	368	190	353	421	206	409	1,005
Canned[1]	1,062	1,385	1,100	1,313	1,836	2,075	6,022	7,764	5,900	4,917	7,323	8,597
Cured	531	25	16	119	137	210	1,142	73	21	277	306	396
Subtotal	7,297	17,451	10,582	4,370	15,194	7,699	12,321	28,108	17,338	8,386	26,332	24,537
Shellfish												
Shrimp												
Fresh or frozen	248	119	92	177	40	176	2,277	1,828	1,478	2,990	271	1,964
Canned				2	1	33				2	1	292
Other												
Fresh or frozen	1,730	1,953	2,560	2,801	3,316	4,445	5,478	4,858	5,368	6,940	7,858	11,374
Canned	7	13	6	9	11	8	44	72	42	41	48	38
Subtotal	1,985	2,085	2,658	2,929	3,367	4,662	7,799	6,758	6,888	9,973	8,178	13,668
Grand total	9,282	19,536	13,240	7,299	18,562	12,361	20,120	34,866	24,226	18,359	34,510	38,205

[1]Primarily canned anchovies

ery products over the previous 5 years, U.S. exports of edible fishery products to Spain have declined since 1983, when 2,204 t of U.S. fishery products valued at $4.5 million were purchased by Spanish importers. These products consisted of frozen squid (1,934 t valued at $3.6 million) During 1983, the Government of Spain restricted imports of *Loligo patagonia* squid to compensate for the glut of inexpensive squid entering Spain from East European countries, especially Poland. U.S. exports of squid, however, were not affected by the import restriction and U.S. squid exporters selling in Spain enjoyed a banner year. Other U.S. products traditionally exported to Spain have included frozen salmon, other frozen fish (mackerel and herring), and cured fish (salted cod).

The inability of U.S. seafood exporters to successfully penetrate the Spanish seafood market is curious. The United States has allowed Spanish vessels to fish in United States waters since the 1960s. Spain was one of the first nations to request a Governing International Fishery Agreement (GIFA) with the United States to allow Spanish vessels continued fishing inside the United States 200-mile limit, which was extended in 1976. In addition, Spain was the first European country to receive allocations of fish in the United States 200-mile zone in exchange for a promise to facilitate the importation of seafood from the United States; this "fish and chips" agreement was negotiated in 1980. Several United States seafood sales missions and a United States Seafood Exhibition at the ALIMENTARIA Food Show held in Barcelona were used to increase United States visibility on the Spanish market. However, despite the existence of the "fish and chips" agreement and allocations to Spanish vessels, Spanish imports of United States fishery products decreased (Fig. 3).

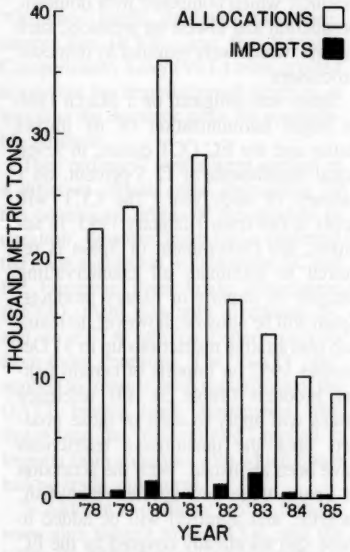


Figure 3.—Spanish imports from the United States, vs. allocations in U.S. waters, by quantity, 1978-85.

U.S. Seafood Imports from Spain

Since 1980, United States imports of edible fishery products from Spain have fluctuated, due primarily to the varying amounts of tuna purchased by United States importers from year to year (Table 5). A record amount of Spanish seafood, 19,500 t valued at $35 million, was imported by the United States in 1981. Commodities making up the largest portion of that amount were fresh or frozen tuna and frozen "other" shellfish, reportedly squid. Imports during 1983, however, fell to 7,300 t, valued at $18 million, primarily because tuna imports fell sharply that year, while "other" shellfish imports remained relatively constant. U.S. import data for 1985 indi-

cate that the United States purchased 12,400 t of Spain's edible fishery products, valued at $38 million. During 1985, imports of Spanish products represented about 1 percent of United States worldwide fishery imports.

Fish

Finfish generally make up about two-thirds of the U.S. imports from Spain. The most important single species is tuna, but in 1985, the United States began to purchase significant amounts of swordfish for the first time.

Tuna: U.S. imports of fresh or frozen tuna from Spain since 1980 have been erratic at best, with a high recorded during 1981 of 15,900 t, valued at $19 million, and a low of 2,800 t, valued at $2.7 million imported during 1983. The majority of those imports consisted of skipjack tuna. Small amounts of albacore, yellowfin tuna, and other tunas made up the majority of Spanish tuna exports to the United States in 1980, 1982, 1984, and 1985.

Swordfish: U.S. imports of Spanish-landed swordfish have increased dramatically in the past 2 years. The United States imported no swordfish from Spain until 1983, when 15 t, valued at $0.3 million was reported. During 1985, however, the U.S. importers bought 1,300 t of swordfish worth $7 million, or 9 times as much as they purchased in 1983. During the first 6 months of 1986, almost 1,000 t of swordfish worth $6 million was purchased by U.S. seafood importers.

Others: The "other" fish category includes negligible amounts of mackerel and cod, in various forms. "Other" fish imports have been traditionally negligible, averaging only about 1000 t annually since 1980. Imports during 1985, however, reached a high of 368 t, valued at $1 million. Canned fish imports from Spain since 1980 have consisted primarily of anchovies, followed by sardines, mackerel, and bonito, averaging about 1,500 t yearly, with imports during 1985 reaching a record 2,100 t valued at $8 million. Anchovies, 1,300 t worth nearly $7 million, represented more than 50 percent of U.S. canned fish imports from Spain in 1985. Cured fish imports from Spain have usually included small amount of pickled or salted fish.

Shellfish

Shrimp: U.S. imports of Spanish-harvested shrimp have decreased since 1980 when U.S. importers purchased 248 t of fresh or frozen shrimp valued at $2 million. Import data indicate the United States imported 175 t worth almost $2 million in 1985. U.S. shrimp imports from Spain have averaged about 150 t yearly.

Others: U.S. imports of "other" shellfish from Spain have steadily increased during the past 5 years. "Other" imports during 1980 totaled 1,700 t worth $5 million, while 1985 figures reveal that 4,400 t valued at $11 million were purchased by importers. Although, U.S. import statistics do not break down "other" shellfish imports by speices, the NMFS Foreign Fisheries Analysis Branch believes that the majority of this "other" category consists primarily of squid and other cephalopods. Small amounts of fresh, frozen, or canned clams, lobsters, and scallops are also included in this category.

U.S. Seafood Exports to Spain

The United States exports fewer edible fishery products to Spain than to any major country in Western Europe, even to countries with much smaller fishery markets (Table 2). Although total Spanish imports have increased over the past 5 years, the U.S. share of those imports has steadily declined. During 1985, U.S. edible fishery exports to Spain, 295 t, represented less than 0.1 percent of Spain's total seafood imports.

Export Decline

The sustained strength of the U.S. dollar in the past 5 years could explain the decline in United States exports to Spain. The increasing value of the Spanish peseta to the dollar in recent months may contribute to an increase in Spanish imports of U.S. fishery products. The October 1986 dollar value of the peseta was P132.

The decrease in U.S. fishery exports to Spain can also be attributed to increased competition from growing intra-Europe trade, and now, in particular, intra-EC trade. Spanish membership in the EC will certainly put the United States at a further disadvantage in marketing products in Spain. Although the strict import restrictions that have prevented U.S. exporters easy access to the Spanish market will slowly be dismantled, U.S. seafood products will remain at a disadvantage vis-a-vis products from other Member States and countries with which the EC has preferential trade agreements. The exact impact of EC accession on exports from the United States will vary with the products concerned and cannot be presently ascertained.

Despite this lack of U.S. presence in the Spanish seafood market, a recent survey conducted by the U.S. Embassy in Madrid among Spanish seafood importers indicates that 75 percent had an interest in importing U.S. fishery products. The importers mentioned squid, hake, cod, shrimp, monkfish, sole, and live lobster among the U.S. products that they felt had good market potential in Spain.

Species

Significant U.S. seafood exports to Spain have been limited to frozen squid and frozen salmon.

Squid: The most important U.S. fishery commodity exported to Spain between 1980 and 1985 was frozen squid. These exports have accounted for approximately 50 percent of both the quantity and value of total U.S. fishery exports to Spain during the past 5 years, although shipments have fluctuated sharply. Exports fell sharply in 1981, 1984, and 1985. Exports of squid to Spain, 160 t worth $0.2 million, represented 55 percent by quantity and 34 percent by value, of all U.S. fishery exports to Spain in 1985. Although squid makes up more than half of all U.S. fishery exports to Spain, this amount is negligible when compared with Spain's total squid imports. During the first 6 months of 1986, U.S. squid exports to Spain reached 512 t valued at $1 million.

Salmon: Exports of fresh or frozen Pacific salmon have increased steadily since 1980 and reached a high of 150 t valued at $0.5 million in 1984. U.S. salmon exports declined to 109 t, valued at $0.4 million, or a 30 percent decrease in salmon sales to Spanish importers during 1985. Preliminary trade statistics for the first half of 1986 indicated that 50 t, valued at $0.2 million had been exported to Spain.

Others: U.S. exports of "other" fish, primarily fresh or frozen cod and herring, to Spain have been decreasing steadily since 1980, when nearly 800 t, valued at almost $2 million was purchased. "Other" fish exports to Spain, by 1985, had dropped to 30 t worth some $50,000. (Source: IFR-86/57.)

Marine Fisheries in Bahrain

Abdulrahman O. Musaiger

Introduction

Bahrain, one of the Arab Gulf countries, is situated about 24 km off the east coast of Saudi Arabia (Fig. 1). The state is composed of 33 islands with a total area of 691 square km, and has a population of 350,798 (1981 census), of whom about two-thirds are nationals; the rest are expatriates, mainly from Asia, the Middle East, and Europe, respectively (Anonymous, 1986).

Preceding the advent of the oil industry in the 1930's, fishing, boat building, pearl diving, and farming were the traditional Bahraini occupations. At that time, Bahrain was self-sufficient in the production of fish and vegetables, the principal dietary foods. With the development of the oil industry, agriculture and fisheries have declined, and the country became more dependent on imported foods. The national censuses of 1959, 1965, and 1971 showed that over these periods there was a decrease of 1.2 percent per annum in farmers and fishermen (Musaiger, 1982).

Shifting from traditional occupations to more highly paid jobs in the oil industry and other businesses, rapid urbanization, and population growth all contributed to the decline of Bahrain's fisheries. Oil revenue had a limiting effect on the development of agriculture in general and food production in particular. This is because the ratio of investment in agriculture to the total planned investment was very low (El-Sherbini, 1980). Indeed, the contribution of agriculture to gross domestic production in Bahrain does not exceed 1 percent (Musaiger, In press).

Since the end of the 1970's, serious efforts have been focused on development of the fishery sector, resulting a noticeable improvement. Actually, the Bahrain islands are rich in fishery resources with many potentially productive sites on the inhabited coasts. However, the efforts to develop fisheries are facing many difficulties. This paper briefly

Figure 1.—Bahrain and vicinity.

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highlights Bahrain's fisheries and gives some possible measures to develop them.

Fish Landings

From 1979 to 1984, total fish landings increased 80 percent, from 3,901 t to 5,599 t. The two main sectors, artisanal and the industrial fisheries, contributed 76 and 24 percent, respectively. During that period, the industrial sector did not have significant growth (Table 1); its total catch was 1,305 t in 1979, which slowly rose to 1,357 t in 1984. The artisanal sector, using traditional fishing methods, was the principal supplier of fish in Bahrain, and thus more attention should be given its development.

Rabbitfish, shrimps, perches, groupers, and trevallies constituted the main landings in Bahrain (67 percent of total landings). Crustacean fisheries depend largely on shrimps and constituted 80 percent of that category's total. Rabbitfish is the most popular finfish in Bahrain, and is the most heavily harvested. The contribution of rabbitfish to the total landings of finfish increased from 11.9 percent in 1979 to 19.7 percent in 1984. Groupers came in second, although their contribution to the total landings decreased from 13.4 to 11.5 percent during the years 1979 and 1984, respectively (Table 2). In general, the finfish catch increased 55.5 percent, and the crustacean catch by 230 percent while the mollusk catch rose 464.3 percent during 1979-84.

Table 1.—The contributions of imports and the artisanal and industrial fisheries to the total fish consumed in Bahrain during 1979-84 in metric tons (t).

	Artisanal		Industrial		Imports		Total	
Year	t	%	t	%	t	%	t	%
1979	2496	52.8	1305	27.6	927	19.6	4728	100.0
1980	2877	46.4	2238	36.1	1090	17.6	6205	100.0
1981	3599	47.7	2148	28.5	1803	23.9	7550	100.0
1982	2750	49.8	1844	24.5	1932	25.7	7526	100.0
1983	3303	41.9	1509	19.1	3081	39.0	7893	100.0
1984	4242	49.2	1357	15.7	3021	35.0	8620	100.0

Table 2.—Total landings in Bahrain by fish species for the period 1979-84 in metric tons (t).

	1979		1984	
Fish group	t	%	t	%
Finfishes				
Rabbitfishes	451	11.9	1,105	19.7
Perches	688	18.1	656	11.7
Groupers	509	13.4	642	11.5
Trevallies	321	8.5	522	9.3
Mackerels	85	2.2	221	4.0
Parrot fishes	91	2.4	152	2.7
Sea breams	53	1.4	137	2.4
Grunts	80	2.1	104	1.9
Silver biddies	6	0.2	94	1.7
Snappers	247	6.5	88	1.6
Others	1,051	27.5	842	15.0
Crustaceans				
Shrimps	182	4.8	808	14.4
Crabs	23	0.6	162	2.9
Shovel lobsters	2	0.1	16	0.3
Molluscs				
Sepia, clamars	10	0.3	50	0.9
Total	3,801	100.0	5,599	100.0

Landing Facilities

About 51 fishing sites are distributed around the islands of Bahrain. Unfortunately, many of these sites have no landing facilities (Table 3). The majority of these sites lack facilities for providing ice, fresh water, fuel, and mooring piers. Beach landing and marketing facilities were available in 86.3 percent of the fishing sites. The facilities available for artisanal fisheries were poor compared with those available for industrial fisheries (Anonymous, 1985a).

Table 3.—Landing facilities in all fishing sites in Bahrain (1983).

	Availability			
	Yes		No	
Facilities	No.	%	No.	%
Mooring pier	5	9.8	46	90.2
Beach	44	86.3	7	13.7
Fuel	2	3.9	49	96.1
Fresh water	2	3.9	49	96.1
Ice	1	2.0	50	98.0
Marketing	44	86.3	7	13.7

Note: Fishing site is an area used by fishermen either as residence or for boat mooring or landing of his catch.

Labor Force

The number of fishermen has increased from 4,101 to 4,554 during 1978-83, an 11 percent increase, and mostly among Bahraini fishermen, whose numbers rose 13 percent. In contrast, the number of non-Bahraini fishermen decreased 13 percent. There was a 16 percent decline among full-time Bahraini fishermen, and more part-time and occasional fishermen have become involved (Table 4). This implies that some full-time fishermen have shifted to better paying jobs in other sectors, indicating an unhealthy situation, as these fishermen are the most skilled workers.

Handling and Processing

Bahraini fishermen operate wooden and steel vessels, and fish with traps, trawls, and headlines. The fish catch is iced for rapid cooling and held in insulated boxes. Cole et al. (1977) noted that in Bahrain, fish were bulked too deep (to at least 8 feet), which damaged the fish, especially those in the middle and at the bottom of the pile, thus affecting their shelf-life and quality. Cole et al. (1977) recommended the use of pound boards to separate the catch into layers of not more than 2 feet or storing the iced catch in plastic boxes to facilitate the fish handling, especially from the vessel to shore.

Much ice is lost through melting while fish is being transported in open vehicles. Fish transported in open vehicles also suffer spoilage and a reduction in shelf-

Table 4.—Types of fishermen in Bahrain according to their fishing involvement during the 1978 and 1983 censuses.

		Full-time[1]		Part-time[2]		Occasional[3]		Total	
Nationality	Year	No.	%	No.	%	No.	%	No.	%
Bahraini	1978	2,212	59.2	1,331	35.6	195	5.2	3,738	100.0
	1983	1,822	43.0	1,489	35.1	929	21.9	4,240	100.0
Non-Bahraini	1978	321	88.4	32	8.8	10	2.8	363	100.0
	1983	304	96.8	10	3.2			314	100.0
Totals	1978	2,533	61.8	1,363	33.2	205	5.0	4,101	100.0
	1983	2,126	46.7	1,499	33.0	929	20.4	4,554	100.0

[1]One who spends >90 percent of his working hours in fishing.
[2]One who spends 30-90 percent of his working hours in fishing.
[3]One who spends <30 percent of his working hours in fishing.

life due to exposure to direct sunlight[1]. Fish and other marine products are displayed with or without ice in palm-leaf baskets or mats on the ground or on concrete displays, depending upon market facilities. In some big cities, fish marketing facilities are available, including proper display shops, cold storage, and running water. Cleaning, filleting, and/or eviscerating of fish are also provided to the consumers. In many other markets, particularly in rural areas, such handling and processing facilities are lacking.

Most fish are sold fresh, and some are dried or salted. Shrimps are commonly dried, especially at peak seasons. However, as a result of changes in dietary habits, salted fish have become less popular in recent years. Compared with other processed fish, canned fish are highly consumed, and the most popular are tuna, mackerel, and sardine. All canned fish are imported, since there is no fish canning industry in Bahrain. Frozen fish and shrimps are available in supermarkets, and are widely consumed by non-Bahrainis.

Marketing and Distribution

Bahrain has various fish marketing methods. In large towns with a central fish market, storage and fresh-water facilities are available, and the possibility of fish spoilage is relatively low. In some villages which lack such facilities, marketing is done in an open area and the fish are not protected from heat or direct sunlight. Many purchasers, therefore, prefer to buy fish early in the morning or in the afternoon, soon after the catch is landed.

In other villages, especially those far from the sea, small vehicles drive from house to house to sell the fish, which are mixed with ice and covered by wet cloths. These fish may also be exposed to contamination and spoilage, since the vehicles have no proper storage facilities. Local consumers prefer small and medium-sized fish such as rabbitfish and trevallies. Large fish (i.e., groupers) are usually bought by hotels and restaurants.

Fish prices depend mainly on the harvesting seasons. For example the peak season for Spanish mackerel is during the winter months, November-February. Shrimps and rabbitfish landings peak in summer, while groupers are landed throughout the year.

Fish Imports and Exports

Fish imports soared during 1979-84, increasing from 927 t to 3,021 t, respectively. The greatest increase was in fresh, chilled, and frozen fish, which rose 446 percent during the period. Canned fish imports showed the next largest increase, with a rise of 108.7 percent during the same period (Anonymous, 1985b). In 1984, the contribution of imported fish to the total fish consumption in Bahrain was 35 percent, which indicates that Bahrain still lacks self-sufficiency in fish production. A well-designed program, therefore, is needed to encourage the two sectors of Bahrain's fishery, especially the artisanal sector which contributes nearly half of the nation's total catch (Table 1).

Bahrain has not exported any fish or fish products since 1983. Some fish were exported before then, and the amount fluctuated from year to year. In 1979, Bahrain reportedly exported 1,366 t of fish, mostly frozen shrimps[1]. Domestic data (Anonymous, 1985a) indicated that the amount of fish exported in 1979 was 15.3 t or about 1.2 percent of local fish landed that same year. The amount then increased sharply to 179.2 t in 1980 and to 218.9 t in 1981, representing 8.0 and 10.2 percent of total fish landed, respectively. The 1982 exports dropped dramatically to only 21.2 t which represented 1.1 percent of the total fish landed. Most of fish exported were those which not accepted in local markets except by certain expatriates.

Fish Consumption

Annual per capita fish consumption in Bahrain rose from 14.3 kg in 1979 to 21.5 kg in 1984 (Anonymous, 1985b). The 1984 figures are less than that reported by the Central Statistics Organization (1985), as the annual per capita consumption of fish was 34.3 kg for 1983-84, and the consumption was higher among Bahraini (35.8 kg) than non-Bahraini (27.5 kg). This may be due to the fact that fishing is a hobby for many people in Bahrain, especially among Bahraini, and therefore many families consumed more fish that were caught by their members.

Expenditures on fish has also decreased during the past 10 years. The household expenditure on fish during 1973-74 was 13.2 percent of the total food expenditure. This expenditure dropped to 10.2 percent during 1983-84, which was largely due to an increase in the prices of fish and changes in dietary habits as more meat and poultry were consumed, in lieu of fish.

Table 5 shows the annual per capita consumption of various types of fish in Bahrain according to nationality. The Bahraini preferred to consume rabbitfish, groupers, and perches more than non-Bahraini. Annual per capita consumption was 8.4, 7.7, and 5.6 kg, respectively, for the Bahraini, compared with 1.9, 4.9, and 2.1 kg for non-Bahraini.

Composition of Fish Consumed

Little data have been collected on the nutritional values of the fish commonly consumed in Bahrain and other Gulf states. In a Kuwaiti study, Kamel and Allam (1979) examined the nutritional values of some fishes consumed also by Bahrainis. Generally, these fish are rich in protein, which ranged from 19.0 to 21.1 g/100g of edible portion. Dried shrimp is very high in protein (76.4 percent), due to its low moisture content (8.1 percent). Some fish are rich in fat, such as groupers (35.7 percent) and mullets (12.1 percent). Iron is very high in

Table 5.—Per capita annual fish consumption in Bahrain (1983-84).

Type of fish	Consumption (kg)		
	Bahraini	Non-Bahraini	Total
Rabbitfishes	8.4	1.9	7.2
Groupers	7.7	4.9	7.2
Mackerels	2.5	1.6	2.3
Trevallies	1.7	1.5	1.7
Perches	5.6	2.1	5.0
Other fresh fish	4.3	7.6	4.9
Fresh shrimps	4.5	4.7	4.6
Frozen, salted fish	0.3	2.1	0.6
Frozen, dried shrimp	0.6	0.6	0.6
Other sea products	0.2	0.5	0.2
Total	35.8	27.5	34.3

[1]Match. 1982. Country export marketing profiles: Gulf states. Natl. Ocean. Atmospher. Admin., Wash., D.C., p. 1-11.

dried shrimp (62 mg/100g), as well as phosphorus (969 mg/100g). Thus, dried shrimps are very nutritious, but one limitation is their high sodium content.

Constraints on Fishery Development

Several factors influence the development of the Bahrain fishery:

1) Lack of fishing and harbor facilities, particularly ice plants, cold storage, and fuel and marketing facilities.

2) Insufficient investment capital directed to the fishing industry, with most available investment capital directed to poultry, milk, and other food industries.

3) Insufficient research directed to the development of the Bahrain fishery.

4) Inadequate fishery regulation and legislation (i.e., fishing methods, handling, processing, and marketing regulations. Although Bahrain is applying FAO/WHO Codes Alimentarus Standards, the need for local standards is emphasized.

5) Shift of fishermen from the fishing industry to better paying jobs in other industries. This leads to a gradual reduction of the labor force, and particularly, in full-time fishermen.

6) Dredging and land reclamation activities which, along the Bahrain coasts, affects the inshore ecosystem including many corals. The total area dredged in 1982 was about 13,500,000 m^2, while that reclaimed was 9,000,000 m^2 (Al-Alawi, 1982).

7) Lack of modern fishing techniques; this activity is still dependent on artisanal sectors which used traditional fish capture methods.

8) Shortage of qualified manpower in various aspects of fishery science. Saleh (1986) explained that the lack of qualified persons in the fishing industry may be due to socioeconomic factors, as fishing became less attractive to the new generation, and hence fewer people were involved in this sector.

9) Regional and government restrictions. The FAO (1978) reported that grounds fished by Bahrainis are also fished by fleets from neighboring countries, so domestic catches are influenced by the activities of the other fleets. Also, fishing is prohibited in some areas owing to local industrial and defense institutions (Saleh, 1986).

10) Pollution of the sea either by spilled oil, industrial waste, or untreated sewage.

11) Increase in prices of fishing gear and other related equipment.

Conclusions

Although Bahrain has increased fish production, the rise in population and the high demand for fish (especially fresh fish) has made it difficult to rely on local fish. As a result, fish imports have increased annually. Additionally, there are many barriers to developing the marine fisheries in the country. To develop Bahraini fishery resources, the following measures should be considered:

1) Providing basic facilities for landing, handling, processing, and marketing of fish in Bahrain.

2) Introducing modern techniques, and improving traditional fishing methods.

3) Stimulating local fishermen to be more involved in fisheries by improving access to credit and gear technology.

4) Establishing local regulations and legislation for fisheries in Bahrain. This could be done through assistance from other related international organizations.

5) Controlling dredging and reclamation activities through regulations, and carrying out geological and bioecological surveys in areas where dredging or reclamation is planned (Al-Alawi, 1982).

6) Training in different aspects of fishery science.

7) Encouraging fisheries research and studies, and providing adequate facilities (especially laboratory equipment) to carry them out.

8) Financially subsidizing fishing gear and other fishing equipment to encourage fishermen to enroll in fisheries.

It is important to note that some of these recommendations were considered in the 5-year plan for the development of the fishing sector in Bahrain; however, serious efforts should be put to applying these recommendations.

Recently, the Government of Bahrain, the United Nations Development Programme (UNDP), and the Food and Agriculture Organization of the United Nations have signed an agreement to establish a regional fish marketing service for the Arab World, "INFOSAMAK". The main objectives of this project are to provide information and technical assistance to the fishery industry, to assist in opening up new markets for fish and fish products, to assist exporters of fish products, to generate new investment information in the Arab fishing industry, and to establish a basis for cooperation among the Arab countries in fisheries matters. This project may also help in developing fishery resources in Bahrain and other Arab countries.

Literature Cited

Al-Alawi, S. 1982. Dredging and land reclamation activities along Bahrain coast. Dir. Fish., Minist. Commer. Agric., Bahrain.

Anonymous. 1985a. Fisheries census, 1983. Fish. Stat. Serv., Dir. Fish., Minist. Commer. Agric., Bahrain.

_____. 1985b. Annual statistics report, 1984. Fish. Stat. Serv., Dir. Fish., Minist. Commer. Agric., Bahrain.

_____. 1986. Statistical abstract, 1985. Central Stat. Organ., Counc. Minst., Bahrain.

Central Statistics Organization. 1985. Household expenditure and income survey. Central Stat. Organ., Counc. Minist., Bahrain.

Cole, R. C., C. A. Philbrooks, and L., Nicoladies. 1977. Report on fish handling, preservation, and processing in Bahrain. Trop. Prod. Inst. Rep., Lond.

El-Sherbini, A. 1980. Environmental adversity and food policy in the Arab Gulf States. Food Policy, p. 97-104.

FAO. 1978. Fisheries biologist-shrimp, Bahrain. Terminal Rep. FT:DP/BAH/74/017. Food Agric. Organ. U. N., Rome.

Kamel, B. S., and A. Allam. 1979. Composition of food consumed in Kuwait (Phase I). Kuwait Inst. Sci. Res. Rep.

Musaiger, A. O. 1982. Factors affecting food consumption in Bahrain, Ecol. Food Nutr. 12:39-48.

_____. In press. The state of food and nutrition in the Arabian Gulf countries. World Rev. Nutr. Diet.

Saleh, N. 1986. Development of fish resources in the Arabian Gulf and Red Sea. Pap. pres. at First Conf. Dev. Food Indust., Kuwait Inst. Sci. Res.

Publications

New NMFS Scientific Reports Published

The publications listed below may be obtained from either the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402; from the Publications Services Branch (E/AI13), National Environmental Satellite, Data, and Information Service, NOAA, U.S. Department of Commerce, 3300 Whitehaven St., Washington, DC 20235; or from the National Technical Information Service, Springfield, VA 22151. Writing to the agency prior to ordering is advisable to determine availability and price, where appropriate (prices may change and prepayment is required).

NOAA Technical Report NMFS 42. Appolonio, Spencer, David K. Stevenson, and Earl E. Dunton, Jr. **"Effects of temperature on the biology of the northern shrimp, *Pandalus borealis*, in the Gulf of Maine."** September 1986, iii + 22 p., 25 figs., 7 tables.

ABSTRACT

Length-frequency data collected from inshore and offshore locations in the Gulf of Maine in 1966-1968 indicated that ovigerous female northern shrimp (*Pandalus borealis*) first appeared offshore in August and September and migrated inshore in the fall and winter. Once eggs hatched, surviving females returned offshore. Juveniles and males migrated offshore during their first two years of life. Sex transition occurred in both inshore and offshore waters, but most males changed sex offshore during their third and fourth years. Most shrimp changed sex and matured as females for the first time in their fourth year. Smaller females and females exposed to colder bottom temperatures spawned first. The incidence of egg parasitism peaked in January and was higher for shrimp exposed to warmer bottom temperatures. Accelerated growth at higher temperatures appeared to result in earlier or more rapid sex transition. Males and non-ovigerous females were observed to make diurnal vertical migrations, but were not found in near-surface waters where the temperature exceeded 6°C. Ovigerous females fed more heavily on benthic molluscs in inshore waters in the winter, presumably because the egg masses they were carrying prevented them from migrating vertically at night.

Northern shrimp were more abundant in the southwestern region of the Gulf of Maine where bottom temperatures remain low throughout the year. Bottom trawl catch rates were highest in Jeffreys Basin where bottom temperatures were lower than at any other sampling location. Catch rates throughout the study area were inversely related to bottom temperature and reached a maximum at 3°C.

An increase of 40% in fecundity between 1973 and 1979 was associated with a decline of 2-3°C in April-July offshore bottom temperatures. Furthermore, a decrease in mean fecundity per 25 mm female between 1965 and 1970 was linearly related to reduced landings between 1969 and 1974. It is hypothesized that temperature-induced changes in fecundity and, possibly, in the extent of egg mortality due to parasitism, may provide a mechanism which could partially account for changes in the size of the Gulf of Maine northern shrimp population during the last thirty years.

NOAA Technical Report NMFS 43. Uchida, Richard N., Sigeiti Hayasi, and George W. Boehlert (editors). **"Environment and resources of seamounts in the North Pacific."** September 1986, v + 105 p.

SUMMARY

Presented are 20 papers and session summaries that constitute the proceedings of a workshop held 21-23 March, 1984 in Shimizu, Japan, and cosponsored by the Far Seas Fisheries Research Laboratory, Shimizu; the Honolulu Laboratory, NMFS Southwest Fisheries Center, Honolulu, Hawaii; and the Japanese Society of Fisheries Oceanography, Tokyo. Reviewed are seamount area oceanography and fisheries, population characteristics and biology of pertinent species, stock assessment of pelagic armorhead and alfonsin, and gaps in knowledge about seamounts and future research directions.

NOAA Technical Report NMFS 44. Darcy, George H. **"Synopsis of biological data on the porgies, *Calamus arctifrons* and *C. proridens* (Pisces: Sparidae).** September 1986, iii + 19 p., 26 figs., 8 tables.

ABSTRACT

Information on the biology and fishery resources of two common species of western Atlantic porgies, *Calamus arctifrons* and *C. proridens*, is compiled, reviewed, and analyzed in the FAO species synopsis style.

NOAA Technical Report NMFS 45. Chen, Lo-chai. **"Meristic variation in *Sebastes* (Scorpaenidae), with an analysis of character association and bilateral pattern and their significance in species separation."** September 1986, ii + 17 p., 16 tables.

ABSTRACT

This report presents meristic data for nearly all of the known species of *Sebastes*. Rudimentary caudal ray counts tend to be higher in more active species. The number of caudal rays supported by the hypurals is consistently 14, whereas the number of branched caudal rays varies between 11 and 13. Vertebral counts and most fin-ray counts tend to be lower in species or populations in warmer latitudes, except for pectoral ray counts which tend to have an opposite geographic pattern. On the basis of the small magnitude of meristic and morphometric differences and the lack of other differences between northern and southern samples of "*Sebastes caurinus*," *Sebastichthys vexillaris* Jordan and Gilbert is regarded as a junior synonym of *Sebastes caurinus* Richardson. The patterns of bilateral variation in paired meristics are analyzed and their mechanism discussed. The frequency distribution of pectoral ray counts in their right-left combination is shown to be useful in species separation. No association was found between any combination of two meristic features in any species. The author proposes that intrasample associations between meristic features are evidence of sampling heterogeneity.

NOAA Technical Report NMFS 46. Brodeur, Richard D., and William G. Pearcy. **"Distribution and relative abundance of pelagic nonsalmonid nekton off Oregon and Washington, 1979-84."** December 1986, iii + 85 p., 60 figs., 6 tables, 7 app. tables.

ABSTRACT

Fifteen fine-mesh (32-mm mesh) pelagic purse seine surveys were conducted between 1979 and 1984 off the Oregon and Washington coasts. Environmental conditions varied greatly among the years sampled, and even within years, due to variability in upwelling conditions and productivity and the effects of a strong El Niño from late 1982 to the middle of 1984. In the 843 sets made, a total of 115,891 specimens from 69 taxa was collected. Most individuals collected belonged to nine dominant taxa. Seasonal and interannual variations in the abundance and distribution patterns of these dominant taxa are pre-

sented in detail. A recurrent group analysis delineated four major groupings of nekton.

Genetics and Fishery Management

"Population, Genetics, and Fishery Management, edited by Nils Ryman and Fred Utter, has been published by the Washington Sea Grant Program and is distributed by the University of Washington Press, P.O. Box 50096, Seattle, WA 98195-5096. Ryman is with Stockholm University Genetics Department and Utter is with the NMFS Northwest and Alaska Fisheries Center, Seattle, Wash.

There has not been substantial interaction between the fields of population genetics and fisheries management, the editors lament, and this book is aimed at addressing that void. And, they point out in the Preface, "it has become apparent that fisheries may diminish if the tools and theory of population genetics are not properly applied to the management of these resources." That is one reason that the volume is an important contribution. It began as a series of lectures specifically on population genetics in relation to fisheries management. Those lectures, then, have been augmented with additional contributions from other experts in the field.

In this book, the editors and authors have applied the principles of population genetics to fishery management, excluding only the culture of fishes under controlled conditions throughout their entire life cycle—i.e., cage, pen, or pond-type culture. Few fisheries texts make much more than passing reference to the science of genetics, making this volume is even more useful.

In chapter 1, Fred Allendorf, Ryman, and Utter provide an overview of genetics and fishery management, calling attention to the need for applying the principles of population genetics to the management of natural fish populations and stocks, and providing a look at future directions for genetics in fishery management. In chapter 2, "Interpreting genetic variation detected by electro-phoresis," Utter, Paul Aebersold, and Gary Winans review the collection and interpretation of genotypic data using electrophoretic procedures.

In chapter 3, G. A. E. Gall introduces the basic theory of "Inbreeding" and the closely related concept of random genetic drift (though it is not a review of the consequences of inbreeding). Ranajit Chakraborty and Olof Leimar, in chapter 4, present some of the basic elements of population genetics as applied to subdivided populations, emphasizing methods and results important for the analysis and interpretation of allele frequency data. Then, in chapter 5, Gunnar Stahl provides an overview of the genetic population structure of the Atlantic salmon, *Salmo salar*, over the species' entire range by examining genetic differences among natural populations and hatchery stocks from the various geographic regions.

Allendorf and Ryman then discuss genetic management of hatchery stocks in chapter 6 while in chapter 7 Donald E. Campton reviews pertinent literature on the application of population genetics to investigations of hybridization problems in fisheries management, and discusses the use of morphological characters for detecting natural hybridization. Then, Masatoshi Nei examines in chapter 8, genetic distance and molecular phylogeny, while W. Steward Grant covers genetic divergence between congeneric Atlantic and Pacific Ocean fishes in chapter 9.

In chapter 10, Jerome J. Pella and George B. Milner relate the use of allelic variants as genetic marks, with particular emphasis on estimating the contribution of different stocks to mixed-stock fisheries, while in chapter 11, Stephen D. Ferris and William J. Berg address the utility of mitochondrial DNA in fish genetics and fishery management. That is followed by a presentation of inter- and intraspecific variability patterns observed in salmonids (chapter 12). Chapter 13 reviews methods for induction of polyploidy and gynogenesis, and describes the most likely management roles of chromosome markers and manipulations in fishes.

The book then ends with two chapters related to the understanding, use, and conservation of genetic resources. The unique local adaptation of natural populations is discussed in chapter 14 and is suggested as a basis for modifying current management activities. Chapter 15 considers the effects of fishing and hatchery practices on the gene pools of exploited species, pointing out problems inherent in current harvesting policies and suggesting corrective courses of action.

The 24 contributors are principally geneticists, and although some of the contributions are quite technical, especially to those not schooled in the rudiments of genetics, it should still be of considerable use, as both a text and a reference and perhaps will help encourage the application of the principles of population genetics to fisheries management. Paperbound, the 420-page volume is available from the UW Press for $17.50 (paperbound) or $35.00 clothbound.

Biology and Management of Snappers and Groupers

In May 1985 the Honolulu Laboratory of the NMFS Southwest Fisheries Center sponsored a workshop on the biology and management of regional snapper and grouper stocks. Now, the proceedings have been published as **"Tropical Snappers and Groupers: Biology and Fisheries Management,"** edited by Jeffrey J. Polovina and Stephen Ralston of that Laboratory, by the Westview Press, 5500 Central Avenue, Boulder, CO 80301.

In sum, the book presents an excellent international perspective on those fishes, with the first half devoted to their taxonomy, reproductive biology, early life history, growth, mortality, and community-trophic interactions. Additional chapters examine the assessment and management of fisheries for snappers and groupers in Australia, Hawaii, and the Marianas, the southeastern United States, and the Gulf of Mexico and the Caribbean. Discussed are historical trends within the fisheries, methods of harvest are described, and analytical methods to provide estimates of population and yield parameters are evaluated and applied. A final chapter by John L. Munro draws together and summarizes the workshop presentations and suggests future research needs.

More specifically, in the first part, "Biological Reviews," William Anderson outlines the systematics of the Lutjanidae while Gerald Allen presents a synopsis of the circumtropical genus Lutjanus. John Randall gives a preliminary synopsis of the groupers of the Indo-Pacific region. Then, Jeffrey Leis re-

views the early life history of tropical groupers and snappers, Churchill Grimes reviews the reproductive biology of the Lutjanidae, and Douglas Shapiro discusses grouper reproduction. Charles Manooch III reviews age and growth of snappers and groupers, Stephen Ralston examines mortality rates of both groups, and James Parrish details their trophic biology.

Snappers and groupers are large apex predators which are important fishery resources in many tropical and subtropical waters. This collection of reviews and data on these fishes, which are important commercially and recreationally, should be a reference of wide interest and use to many fisheries biologists and managers. The 659-page paperbound volume, part of Westview Press' Ocean Resources and Marine Policy Series, is available from the publisher for $43.50.

The Aging and Growth of Fish

"Age and Growth of Fish," has been published by the Iowa State University Press, Ames, IA 50011. Managing editor for the volume was Robert C. Summerfelt and technical editor was Gordon E. Hall. Presented are 37 of 73 oral and poster papers from the International Symposium on Age and Growth of Fish held in Des Moines, Iowa, 9-12 June 1985. The symposium served a dual purpose—as a forum for those studying the age and growth of fish and to honor the professional life of Kenneth D. Carlander upon his retirement from the faculty of Iowa State University. Also included are three additional papers to add depth to the coverage. "Techniques for the estimation of RNA, DNA, and protein in fish" by Lawrence J. Buckley and Frank J. Bulow, and "Uptake of ^{14}C-glycine by fish scales (in vitro) as an index of current growth rate" by Greg P. Busacker and Ira R. Adelman were added to provide basic biochemical methodology for the study of current growth rate; "Methodological approaches to the examination of otoliths in aging studies" by E. B. Brothers was included to provide insight for the study of otoliths from the author's experience. A glossary, developed by a "Glossary Committee" chaired by C. A. Wilson, will allow a better understanding of basic terminology and help to standardize them.

Research on the aging of fish has made great strides in the last couple of decades, as evidenced by this symposium and volume. The book's subject matter is taxonomically diverse, including clams and lobsters, sharks, and bony fishes in freshwater and marine habitats ranging from tropical and temperate areas, to mountain streams and man-made lakes. The topics ranged from study of length-frequency distributions, enumeration of marks on hard parts—including scales, otoliths, bones, and spines—validation methods, biochemical procedures for study of short-term growth, and mathematical-statistical considerations for back-calculating and describing fish growth.

The contributions are arranged in seven parts: Part I, History, problems, and current status; Part II, Characterization of growth; Part III, Variability, error, and bias; Part IV, Validation; Part V, Methods; Part VI, Larval and juvenile fish aging and studies; Part VII, Applied studies.

Some topics of interest include Carlander's history of scale age and growth studies of North American freshwater fish, and "Current trends in age determination methodology" by Richard J. Beamish and Gordon A. McFarlane. Frank Bulow presents a review of RNA-DNA ratios as indicators of growth in fish while Ira. R. Adelman reviews "Uptake of radioactive amino acids as indices of current growth rate of fish." Other articles address linear models for the growth of fish, estimating and interpreting annual growth rates, reliability of age and growth-rate estimates derived from otolith analysis, lack of first-year annuli in scales of western trout validating daily increment deposition in otoliths of larval fish, use of tagging programs to validate scale readings, validation of dorsal spine method of aging spiny dogfish, use of microcomputers in age and growth studies, age determination of ocean bivalves, and much more. This is a large and impressive volume which presents much important and recent research on the topic, as well as several substantive reviews, and it is an excellent representation of contemporary research. It also includes an extensive and useful bibliography and subject and taxonomic indexes. The 544-page hardbound volume is available from the publisher for $34.95.

Studies on Fish Behavior and Fisheries Management

The *Journal of Fish Biology* has published for the Fisheries Society of the British Isles the FSBI Symposium entitled **"The Behaviour of Fishes,"** edited by T. J. Pitcher, A. E. Magurran, and A. R. Margetts. Pitcher and Magurran are with the School of Animal Biology, Univeristy of Wales, and Margetts, *JFB* editor, is with the Fisheries Laboratory, Lowestoft, Suffolk, England.

Papers accepted for this issue of the *Journal* center on themes of reproductive behavior (i.e., mate selection), schooling behavior and fish movement, foraging behavior (i.e., constraints on optimality), aggression, development, and behavioral physiology. Keynote papers published here include G. P. Baerends on causation and function of the prespawning behavior of cichlids; G. W. Barlow on mate choice in the monogamous and polychromatic Midas cichlid, *Cichlasoma citrinellum*; and M. Milinski's review of competitive resource sharing under constraints in sticklebacks.

Additional papers of interest include those on tilting behavior of the Atlantic mackerel, *Scomber scombrus*, at low swimming speeds by P. He and C. S. Wardle; heart rate as an indicator of activity, metabolic rate, food intake, and digestion in pike, *Esox lucius*, by J. D. armstrong; behavior of the abyssal grendier, *Coryphaenoides yaquinae*, monitored using ingestible acoustic transmitters in the Pacific Ocean by I. G. Priede and K. L. Smith, Jr.; migrational swimming speeds of the American shad, *Alosa sapidissima*, in the Connecticut River by H. M. Katz; development of feeding behavior in larval lumpfish, *Cyclopterus lumpus*, by J. A. Brown; development of schooling behavior in the European minnow, *Phoxinus phoxinus*, by A. E. Magurran; a light intensity threshold for schooling in the Atlantic mackerel, *S. scombrus*, by C. W. Glass et al.; predation and minnow schooling at twilight by T. J. Pitcher and J. R. Turner; visual cues determining prey selection by the turbot, *Scophthalmus maximus*, by

R. A. Holmes and R. N. Gibson; optimal foraging behavior in the rainbow trout, *Salmo gairdneri*, by M. Bres; and a test of a size-selective predation model with juvenile brook charr, *Salvelinus fontinalis*, by J. W. A. Grant and D. L. G. Noakes. Other papers discuss mate choice in various cichlids, causes and function of prespawning cichlid behavior, influence of species composition on behavior in mixed-species cyprinid schools, and size sorting in minnow schools.

The 232-page paperbound symposium was published as Supplement A to Volume 29 of the *JFB*; a separate index to the issue is provided and it is sold by Academic Press Inc. (London) Limited, High Street, Foots Cray, Sidcup, Kent DA14 5HP England (individual copy price not listed), and should be of interest to those studying or researching aspects of the behavior of fishes.

Another FSBI symposium also published by the *Journal of Fish Biology* is **"The Scientific Basis of Inland Fisheries Management,"** convened by R. Williams and edited by Williams, A. R. Margetts, and J. M. Elliott. Williams is with the Department of Applied Biology, University of Wales Institute of Science and Technology, Cardiff; Margetts is *JFB* editor; and Elliott is with the Freshwater Biological Association, Windermere Laboratory, Ambleside, England. Symposium topics included salmonids and the factors influencing their management; environmental impacts of fish farming and of pesticide discharges; sampling methods and water quality standards for nonsalmonids; fluctuations in year-class strength and management strategies for selected fisheries; and the use of models and environmental indices in fisheries management. The papers concern both fisheries for gamefish alone and for species sought by both commercial and sport fishermen.

Topics of interest include some fundamental research problems in the management of Atlantic salmon, *Salmo salar*, in Canada by E. M. P. Chadwick; factors governing the production of juvenile Atlantic salmon in Scottish streams by H. J. Egglishaw and P. E. Shackley; population dynamics of the migratory brown trout, *Salmo trutta*, in an English stream and their implications for fisheries management by J. M. Elliott; salmon stock and recruitment, and stock enhancement by D. J. Solomon; brown trout growth and survival factors in different types of streams by M. Zalewski et al.; habitat evaluation as a fisheries management tool by N. J. Milner et al.; and the environmental impact of salmonid cage culture on inland fisheries by M. J. Phillips et al.

Other papers discussed possibilities of improving catchable fish stocks in lakes undergoing eutrophication, an evaluation of pulse fishing for the walleye, *Stizostedion vitreum vitreum*, in Henderson Lake, Ontario, a pike culling strategy for trout management in the River Avon, environmentally induced fluctuations in year-class strength and their implications for fishery management, survey methods and various sampling strategies for fish population assessment; cost effective sampling of fish populations in large water bodies; and the assessement of flow characteristics at certain weirs in relation to the upstream movement of migratory salmonids.

The volume provides an interesting and useful variety of papers on some of the biotic, chemical, and physical factors that impinge on the management of inland fisheries and anadromous fishes. The 300-page paperbound issue—Supplement A to Volume 27 of the *JFB*—is available from the publisher (single copy price not given).

Marine Photochemistry, Pollution Study Progress

"Sources and Fates of Aquatic Pollutants," edited by Ronald A. Hites and S. J. Eisenreich, has been published by the American Chemical Society, 1155 Sixteenth Street, N.W., Washington, DC 20036 as No. 216 in its Advances in Chemistry Series. The volume was developed from a symposium sponsored by the ACS Division of Environmental Chemistry.

Only in the past decade, the editors point out, have the processes controlling the transport and fate of inorganic and organic species in limnic and marine environments been delineated, and the processes are studied with a holistic approach to aquatic pollutant chemistry, in which the atmosphere, water, and sediment are considered interdependent compartments of an ecosystem. This volume, in 16 chapters, presents this holistic approach and describes the relationship between physical mixing rates and chemical reaction rates in four sections: Air-water processes, water column processes, water-sediment processes, and case studies. The first three sections emphasize the chemical and physical processes controlling solute behavior and fate in air and water, while the case studies integrate information on those processes into a systemwide picture of the cycling of inorganic and organic chemicals. Specific topics include environmental modeling of hydrophobic organic compounds, air-sea transfer of trace elements, vapor-particle partitioning of semi-volatile organic compounds, and metal speciation in natural waters. Other topics include mechanisms controlling the distribution of trace elements in oceans and lakes, the role of particulate matter in the movement of contaminants, PCB's in Lake Superior, element cycling in wetlands, and much more. The volume will be a very useful reference for advanced students and marine and atmospheric scientists who deal with these problems. Hardbound, the 558-page volume is available from the ACS Distribution Office at $99.95 (U.S. and Canada) and $119.95 elsewhere.

Also published by the ACS as ACS Symposium Series 327 is **"Photochemistry of Environmental Aquatic Systems,"** edited by Rod G. Zika and William J. Cooper. The book was developed from a symposium sponsored by the ACS Divisions of Geochemistry and Environmental Chemistry. The field of aquatic photochemistry encompasses a wide diversity of areas with environmental science. However, the study of photochemistry in aqueous solution, and in particular its application to environmental processes, is relatively new. Natural waters receiving solar radiation are active photochemical reactors, while naturally occurring humic substances are relatively efficient initiators of photochemical reactions. This 20-chapter volume, the first to deal specifically with marine and freshwater photochemistry, is therefore a

valuable source of information for scientists and students in the field.

Following an introductory overview, the remaining chapters are presented in five sections: Transformation of xenobiotic compounds, inorganic photooxidants, photosensitization in natural waters, heterogeneous reactions, and modeling and actinometry. Some of the topics covered in individual chapters include photolysis of phenol and chlorophenols in estuarine waters, the mechanism of photolytic ozonation, time-resolved fluorescence measurements on dissolved marine organic matter, catalyzed photodegradation of two herbicides, and photochemical modeling as applied to natural waters. Others include photochemistry of copper complexes in sea water, consequences of OH radical reaction in sea water, natural photosensitizers in sea water (riboflavin and its breakdown products), and more. The 288-page hardbound volume is available from the ACS for $54.95 (U.S. and Canada) and $65.95 elsewhere, and the volume should be of interest to environmental and marine chemists and biologists.

A GUIDE TO THE PERCHES

Publication of **"The Biology of Perch and Related Fish"** by J. F. Craig has been announced by Timber Press, 9999 S.W. Wilshire, Portland, OR 97225. The author is a research scientist with the Freshwater Institute, Department of Fisheries and Oceans, Winnipeg, Canada.

Certain members of the perch family are economically important, both as food and sport fishes, and have been extensively studied. These include the perch and zander of Eurasia and the yellow perch and walleye of North America. Other common members of the family include the ruffe, sauger, and several species of the three genera of darters. In this book, the author reviews and summarizes important aspects of the biology of the perches and highlights areas needing future research. Following an introductory chapter on percid taxonomy, the bulk of the book is then devoted to the biology of the species *Perca* and *Stizostedion*.

Obviously an immense volume could be devoted to such a topic; however, this smaller volume presents a well-rounded introduction to and reference on the perches and their biology. The author covers in some detail perch anatomy and morphology, growth, mortality and longevity, and reproduction and development. Other topics covered include food, feeding, and energetics; physiological processes and movements; parasites and diseases; adaptation, evolution, and genetics; population dynamics and community structure; and the fisheries and economic importance of various species along with their exploitation, culture, and vulnerability to pollution and other environmental perturbations. The final part of the book is devoted to very brief synopses of the biology of other percids (*Gymnocephalus* and *Percarina*) and the Etheostomatini and the Romanichthyini. Well illustrated, the book also includes a bibliography and author index as well as a subject index, and is a fine, succinct reference to an important family of fishes. The small format 333-page hardbound volume is available from the publisher for $42.50 plus $3.00 shipping and handling.

The New England Fishing Industry and How It Works

"The New England Fishing Economy" by Peter B. Doeringer, Philip I. Moss, and David G. Terkla, has been published by the University of Massachusetts Press, P.O. Box 429, Amherst, MA 01004. It is subtitled "Jobs, Income, and Kinship" and is a thorough look at the structure and workforce of that region's fishing industry and how it has adapted to various changes. Of interest to many readers will be the contrast revealed between capitalist, collective bargaining, and kinship practices governing jobs and income in the industry, which is then related to fisheries regulation. The authors are members of the Department of Economics and are associated with the Institute for Employment Policy at Boston University.

The volume is the result of team research begun in late spring 1982 to determine how a shift in the U.S.-Canadian fishing boundary would affect socioeconomic conditions in New England. Much of the literature on fisheries policy and regulation, say the authors, assumes that the movement of resources in and out of the fishing industry is relatively easy; however, they believe that their book shows that the assumption of such flexibility is incorrect. Downward adjustment in the work force is difficult, they report, at least for the core of the New England fishing industry, due in part to labor market conditions in fishing ports, but mainly to social and institutional mechanisms that tie resources to the industry. The result, they say, is that resources often remain idle during bad times rather than being reemployed outside the industry.

Case study analysis concentrated on the ports of Gloucester and New Bedford, Mass. The book is presented in two parts, and Part I develops background materials on the New England fishing industry, its work force, and the local port economies, including an overview of the changes in the fishing industry in New England since 1960, the economic trends and economic and institutional setting of fishing and fish processing in Gloucester and New Bedford, and an examination of the social and cultural dimensions of the labor force in fishing and processing in the two ports.

Part 2 addresses the dynamics of adjustment to economic change—examining adjustments in employment and income within the fishing industry in response to economic change, describing institutional rules governing employment and pay in different parts of the fishing industry, and demonstrating how these rules operate to determine the incidence of change within the industry. Explored is the question of employment flows between fishing and the rest of the economy, the extent of skill transferability, the comparability of earnings, and the income and employment alternatives for displaced fishermen and processing workers. A final chapter presents the conclusions and develops a series of recommendations for fisheries management policies. The 147-page hardbound volume is available from the publisher for $22.50.

The Ecology of Tropical Fishes

"Ecological Studies in Tropical Fish Communities," by R. H. Lowe-McConnell, has been published in the Cambridge Tropical Biology Series by the Cambridge University Press, 32 East 57th Street, New York, NY 10022 in both paper and hardbound editions. Many tropical fish communities are of considerable scientific interest as they provide an excellent outdoor laboratory for studying evolutionary processes, as well as providing a wealth of information for those studying theoretical aspects of community ecology. Likewise, reef fishes also provide excellent data for assessing the costs and benefits of different types of social and reproductive behavior. In this new volume, the author compares information on the ecology of fishes from tropical fresh waters and seas to examine general principles and to identify gaps in knowledge. Some of the material has been treated in the author's two earlier books ("Fish Communities in Tropical Freshwater" and "Ecology of Fishes in Tropical Waters"). This new volume, though, is an updating of his earlier ones, and a reinterpretation of portions of it in light of more recent studies.

The book has 14 chapters arranged into four parts—an introductory section, freshwater studies, marine studies, and four syntheses: Responses of fishes to conditions in tropical waters, trophic interrelationships, the maintenance and evolution of diversity, and, finally, a look at the exploitation and conservation of tropical fish stocks.

Following an overview of the ecology of tropical freshwater and marine environments and their associated fish faunas, the author relates a number of freshwater studies drawn from the African, South American, Asian, and New Guinean tropics. Special consideration is given to the new man-made lakes which have provided large-scale experiments on the change of riverine fish communities to lacustrine ones, and to the great lakes of East Africa for examples of recent species evolution.

The marine section describes direct observations of coral reef fishes and discusses how the great diversity of reef communities is maintained. It also examines data from trawl surveys and from pelagic fisheries, especially for sardines in coastal upwellings and tuna from open seas.

In the synthesis section, the responses of fish to the varied conditions in tropical waters are discussed, including the effect of seasonality upon life history strategies, and how these enable so many species of fish to coexist. The final chapter deals with man's utilization of tropical fish, and their production and conservation.

The volume concludes with an appendix of fish families in tropical waters, and an extensive list of references. With its broad and comprehensive coverage, the volume should become a well-used reference on the ecology of tropical fish communities and be a good source of material on tropical fisheries biology, ecology, and behavior. Indexed, the 382-page volume is available from the publisher for $64.50 (cloth) and $22.50 (paper).

Seal Controversies in Atlantic Canada

Such marine mammals as seals are seen by some as a harvestable food or fur resource, a competitor for fish, and by others as creatures needing love and full protection for various ethical or moral reasons. Many of those views, and the holders of them, are discussed in the book **"Seal Wars! An American Viewpoint,"** by Janice Scott Henke, published by Breakwater Books, Ltd., 277 Duckworth Street, P.O. Box 2188, St. John's, Newfoundland, Can., A1C 6E6. The New York author is a cultural anthropologist and cultural resources consultant who also is a licensed New York State wildlife rehabilitator.

In one sense, the book is a fundamental look at the Canadian sealing industry from the days when east coast sealing was considered "the greatest hunt in the world" to the present when it has been virtually halted by animal-rights groups. It is the culmination of 4 years of research by the author on seal ecology, seal harvests, the sealers, and the anti-seal-hunt protection groups. The subject, she candidly admits, is one "on which no feeling, compassionate human can remain entirely neutral."

The book is sympathetic toward those people who have been most affected by the seal-hunt protests—the Inuit of Greenland and Canada and the Newfoundlanders and other Maritimers who have hunted seals on a subsistence basis for hundreds of years. And in reviewing the rise of the various anti-seal-hunt groups, it is critical of the emotionalism and, especially, of the effect of the hunting protests have had on the Native cultures. Thus, the book casts unique light on a highly controversial issue. In a postscript to the book, the author states her belief that there was no justification for abolition of Canada's harp seal hunts, and that descriptions of the seal hunts on seal herds were incorrect, as were claims of cruelty to the seals. At any rate, she has provided another look at the problems involved in trying to manage a natural resource on the basis of differing views of "morality," and for that reason it makes for some interesting and instructive reading. The 215-page paperbound volume is available from the publisher and costs $9.95.

Another Look at the LOS Treaty

"The 1982 Law of the Sea Treaty," published by Washington Sea Grant Communications, University of Washington, HG-30, 3716 Brooklyn Avenue, N.E., Seattle, WA 98105, is subtitled "One observer's assessment of the conference, the treaty and beyond." Presented by law professor Thomas A. Clingan, Jr., it is the 12th in the series of McKernan Lectures established by the UW. Here, the author provides a rather personal account and interpretation of the conduct and outcome of the LOS treaty and its effectiveness, and he attempts to answer the question: "Is the LOS Treaty a success or a failure?" He also speculates on the future of the LOS Treaty in the context of several possible scenarios and cautions against nations adopting short-term, bilateral solutions to problems that might "undermine the international public order." The paperbound 19-page treatise, WSG 86-1, is sold by the publisher for $3.00.

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